

MODULE 13

CODES AND

STANDARDS



7250 West Credit Avenue, Mississauga, Ontario L5N 5N1 Tel: (905) 542-2176 Fax: (905) 542-1318

Codes and Standards

Module 13

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INTRODUCTION

Scope of the Module

Standards play a key role in the performance and output of any modern industrial nation. Most welding personnel, supervisors, engineers, and inspectors are in daily contact with references to various codes and standards, and a clear understanding of their purpose, origin, and use is essential. This module has been developed to provide this.

The main objectives of the module are:

first - to provide a general overview of the welding and welding related standards system in Canada with a thorough and comprehensive review of all those standards of prominence that are judged to either have a dominating or profound influence on welded construction in the country or have affected it significantly.

Briefly reviewed will also be other standards, primarily those of governing stature which choose to cover welding requirements by referencing pertinent major welding standards.

The interrelation between standards and its significance in the consolidation of the welding technological background of the engineering personnel will be noted.

second - to review the standardization system in the USA with respective consideration of all major standards developing organizations, their function and objectives. Included in this review will be a brief discussion of those welding related standards that are of established reputation and are acclaimed as leaders in their respective fields, but which also have a special bearing on the formulation of Canadian standards.

third - to briefly overview the *international* standardization activity so as to provide a better understanding and more meaningful appreciation of the potential global trends and future developments. Furthermore, reference will be made to national standards developing organizations in a number of leading industrial countries around the world. Interrelations between standards will be pointed out.

fourth - to cast a glance at the objectives and the activities of the world renowned International Classification Societies, and finally

fifth - to include in an Appendix a selected listing of mailing addresses of the major standards developing organizations or their marketing agencies.

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It is of extreme importance to note that this module is categorically and emphatically not to be taken or understood as replacing any standard. Its descriptive coverage, where provided, is strictly meant to:

- identify the scope of the standard,
- highlight its more outstanding provisions,
- assist in better perspective appreciation of its specific role within the family of national standards.

The objective of the module is to help remove any detached or fragmentary views, which a practical work exposure to only one or two standards may have created. It aims instead at an overall perspective and balanced understanding and intelligent grasp of the total standards picture.

In the light of this clarification it should be obvious that in the case of any action governed by a specific standard the actual requirements of this very standard must be consulted.

Purpose of Standards

In the present time of rapid developments of new technologies standards can be said to fulfill the all important task of harnessing these developments into product performance or service oriented regulatory constraints setting levels of acceptable quality while taking a responsible stand on protection of public safety.

The ultimate objective of standardization is to build confidence in the user and in so doing stimulate production and commercial activity and in turn markedly enhance the economic well-being of the country.

In more specific terms the function of standards can be said to be:

- to educate - by setting general rules for guidance of producers and consumers,
- to simplify - by reducing the range of variations in sizes, processes, and hence the stock and related record keeping services,
- to conserve - by saving time and materials through ready and official acceptance of developments permitting the use of more advanced design methods and the attainment of higher production efficiencies,
- To certify - by serving as hallmarks of quality and value.

The Canadian structural welding standard system merits separate mention. Its uniqueness lies in the successful combination of advanced material and design standards and their well conceived interlocking with Canada's own home-made certification standards. In the course of years, the latter have managed to establish a respectable level of technological capability in the fabricator's welding engineering and supervisory personnel. This accomplishment can be almost singularly credited with the enviable service performance record of welded steel structures in this country.

Standards - Types and Definitions

The somewhat regrettable fact is that the terms codes, standards, and specifications are not officially used with sufficient differentiation and in a colloquial context are usually taken to

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express the same meaning. However, in order to provide some measure of guidance the following definitions are suggested:

A **specification** is a document, which usually sets forth in some detail the requirements demanded by a buyer for a certain product. It may be, or become, the basis of a contractual agreement between him and the supplier.

The term **standard** is sometimes loosely used instead of specification but more properly it is, as its name implies, a standard by which a product may be judged. The requirements for that product might be embodied into a specification which, if it is generally applicable, would properly be called a "Standard Specification".

The Standards Council of Canada defines the standard as "a document recording approved rules for an orderly approach to a specific activity".

The term **code** is used in the USA as equivalent to **standard** in Canada. Both standard (in Canada) and code (in USA) frequently imply a legal status by virtue of government legislation.

The term **code** in Canada is often considered synonymous with standard or specification or standard specification. However, more often it will be found to incorporate rules of good practice by which the results required by a standard or specification may be obtained. Such document is sometimes explanatory and educational. Hence it occupies a rightful place in the whole spectrum of standardization either as "Recommended Practice" or "Code of Practice".

Any of the three terms imply standardization, but each of them is recognized, without sufficiently clear distinction, to accentuate the different concerns inherent in the whole process of standards development.

Out of the many criteria used for general classification of standards the following may be considered more enlightening, distinguishing between standardization that is:

- *fundamental*, when concerned with weights and measures,
- *dimensional*, when dealing with interchangeability of similar products,
- *functional*, when chiefly concerned with achieving fitness-for-purpose and within this objective dealing possibly with:
 - terms, symbols and definitions,
 - quality, as regards composition and performance,
 - methods or types of tests evaluating workmanship and quality,
 - codes of practice or methods of use to ensure satisfactory performance and safety in service.

It is hoped that in spite of the existing lack of official firmness and stability in the area of terminology the preceding information has helped to shed some light on this aspect of standardization, if only by identifying the problem at hand.

Development of Standards

Most national standards are generated through the voluntary efforts of all segments of society, government and industry, producers and consumers, institutions and individuals.

Codes and Standards

In most western countries the governments freely relinquished their prerogative to impose any degree of control or direction on the standardization system. However, some feel compelled to set up a suitable mechanism designed to prevent overlap and duplication in the system and have developed procedural methods to co-ordinate its output and at the same time ensure the widest possible national acceptance of standards.

This particular function is fulfilled

- in Canada - by the Standards Council of Canada, established by an Act of Parliament,
- in the USA - by the American National Standards Institute.

These two corporations are the subject of detailed discussion later in the module.

Most of the standards of the western world are *voluntary* standards. That means:

- they are developed with the voluntary co-operation of all concerned, and
- the use of the standard by those affected (meaning the specifiers) is also totally voluntary.

Such standards however become mandatory, when so designated by a pertinent regulatory authority or when specified contractually.

The standards are also *consensus* standards, meaning, that everyone who is affected by the development or use of a standard has an opportunity to participate either directly or indirectly through representation or through public review, in the development of the same standard.

Since a balanced representation on a committee is of overriding importance it will serve a good purpose to identify the most common interest groups considered by many standards developing organizations as affecting such representation. These particular groups or rather the individual members of each group are defined by the Standards Council of Canada as follows:

1. **Producer:** in the context of a standards-writing committee, a producer is a representative of an organization involved with the manufacture or promotion of the product, material, or service of concern to that committee.
2. **User:** in the context of a standards-writing committee, a user is an individual or a representative of an organization concerned with the use or application of the product, material, or service of concern to that committee.
3. **General Interest:** in the context of a standards-writing committee, a general interest member is an individual or a representative of an organization who is not associated with the production, distribution, direct use, or regulation of the product. This category is intended to include professional and lay people employed by academic and scientific institutions, safety associations, etc.
4. **Consumer:** in the context of a standards-writing committee, a consumer is an individual who uses goods and services to satisfy his needs and desires rather than to resell them or produce other goods with them.

Standards are developed in many different types of organizations: in companies, trade associations, governmental agencies, technical and professional societies. There is therefore a broad spectrum of possible degrees of consensus that conditions the development of a voluntary

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standard. Hence, by no means must all standards come from the consensus system. Some are intended for use only within a company, an industry, or governmental agency.

However, a standard dealing with a commodity servicing an open market should be developed by a full consensus procedure. Its balanced interest representation will:

- permit it to attain a high level of credibility, and
- make it eligible for recognition as a national standard.

It can be safely claimed that the most effective standards are those developed with the co-operation, goodwill, and understanding of all concerned. In that context the resolution of diverse views is the most important task facing each committee. Such resolution is only possible through mutual concessions on the part of its members, the capability for which in turn relates to their motivation and the calibre of their expertise. An ideal resolution is one that results in the greatest good for the greatest number of people while protecting the interest of all. The art of compromise remains indeed the foremost challenge of a committee.

There is another important point related to development of standards to which particular attention should be drawn.

Some of the standards by virtue of their nature are bound to deal with general situations. As such they cannot be presumed to provide, or even attempt to provide a detailed resolution for every feasible situation that may exist. Their only premise is to provide a broad framework of rules and practices that must be in turn judiciously applied to any specific situation at hand.

In other words, in some instances there must be left—and is left—some room for discretion, some room for judgement—especially engineering and quality control judgement—and it is this judgement that in its best, experience supported form, should be called upon to bear on any final decision.

There are a number of leading national standards developing organizations in different countries. They are associated either with materials, products, systems or services, but they are renowned for their many years of excellent and distinguished contribution to the area of standardization be it nationally or internationally.

Most of them will be given a deserving reference in the module.

Administration of Standards

For the sake of clarity it should be first stated that the term “administration” is taken strictly to imply an ongoing activity on the part of an agency, to which a standard has given a clear mandate to monitor the maintenance of its own requirements.

The classical example of such standards are all the Canadian Standards Association (CSA) welding certification standards irrespective whether concerned with products (electrodes) or organizations. The administration in their case is left in the hands of the Canadian Welding Bureau.

It is the responsibility of the Bureau to monitor, through an appropriate mechanism, the manufacturer's or the company's adherence to the full conditions of the standard under which certification has been granted.

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In the area of boilers and pressure vessels in Canada, this area being under the jurisdiction of provincial governments, it is the designated departments of the appropriate ministries which perform a similar function, but with the extent of this function defined by the applicable Pressure Vessel Act.

In some European countries separate agencies have been established to fulfill the functions similar to those performed by the Bureau. The assignment of these agencies may include an inspection function. However, this function is not within the mandate given to the Bureau.

Where such special agencies are non-existent the regulatory authorities rely on inspection organizations to report on compliance of work performed to specified sections of governing standards.

STANDARDS IN CANADA

Standards Council of Canada (SCC)

For a fully objective grasp of the Canadian standards system, the specific role and function of the Standards Council must be clearly understood.

The SCC is a corporation created in 1970 by an Act of Parliament of Canada. Its purpose as stated in the Act is to foster and promote voluntary standardization in all fields, advancing national economy and facilitating domestic and international trade, and to support international co-operation in the field of standards. It reports to the Parliament through the Minister of Consumer and Corporate Affairs.

In fulfillment of this mandate the Council has the authority:

- to promote co-operation among Canadian voluntary standards developing organizations,
- to accredit within prescribed criteria the above organizations as well as those engaged in certification of products, service, and testing,
- to approve standards prepared by organizations accredited by the Council as National Standards of Canada, and
- to represent Canada in international organizations concerned with voluntary standardization and promote co-operation agreements in the same field between Canada and other countries.

The council carries out its task through:

- the National Standard System (NSS), a federation of independent organizations engaged in standards writing, certification and testing, and
- the Canadian National Committees (CNC)
 - of the International Electrotechnical Commission (IEC), and
 - of the International Standards Organization (ISO).

The Council's International Standardization Branch provides the administrative support for these two national committees and their related technical committees.

The IEC and ISO organizations are briefly discussed later in the module.

The Canadian standards writing organizations accredited by the National Standard System are:

- 1) Canadian Gas Association - CGA
- 2) Canadian General Standards Board- CGSB
- 3) Canadian Standards Association- CSA
- 4) Underwriters Laboratories of Canada- ULC
- 5) Bureau de normalisation du Quebec- BNQ

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Since most of the welding and welding related specifications in Canada are within the domain of the Canadian Standards Association (CSA), its function and its standard writing structure will be briefly discussed first before proceeding with the comprehensive coverage of the highlights of its major standards regulating welding in the construction industry.

Canadian Standards Association - CSA

The Canadian Standards Organization founded in 1919 is a non-profit private sector SCC accredited organization engaged in standards development and certification of products.

The Canadian Welding Bureau (CWB) figuring so prominently in the implementation of many CSA certification standards is a division of CSA although its operation and activities are directed by its own board.

The Standards Policy Board is entrusted with the formulation of regulations governing CSA standardization and is responsible for reviewing all new standards activities through appropriate and authoritative direction of pertinent Standards Steering Committees.

The Standards Steering Committees in turn carry the responsibility:

- in general, for planning, programming, and monitoring all standards-writing activities within their terms of reference and co-ordinating them with those of other organizations or with existing regulations,
- with respect to the Technical Committees this responsibility involves:
 - a) establishing their terms of reference,
 - b) the appointment of their chairmen and vice-chairmen as well as the control of the balanced interest representation of their membership, and finally
 - c) the final approval of all draft standards previously approved by the technical committee.

It will be of interest to note that the most influential standards, the highlights of which will be given by far the greatest attention, are those under the jurisdiction of the Steering Committee on Welding and carry the letter designation "W".

Others, to which only a brief reference is made, are either "Z" designated or letter "S" designated, the latter being the responsibility of the CSA Steering Committee on Structures.

CSA is...

a non-profit, non-government, organization
for developing industrial standards

CWB is...

A Division of CSA charged with
administering welding standards

CSA STANDARD W47.1-1983

"CERTIFICATION OF COMPANIES FOR FUSION WELDING OF STEEL STRUCTURES"

General

The CSA W47.1 Standard is the foremost qualification code in structural welding in Canada.

Its unique concept, born out of the vision of the engineering generation of the nineteen forties, its national implementation entrusted to one central body—the Canadian Welding Bureau—together with its strong inter-linkage with the companion standards CSA W59 and W48 controlling welded construction and certification of electrodes respectively, account for its significant contribution to the success of structural welding and indirectly to the confidence in welding in Canada.

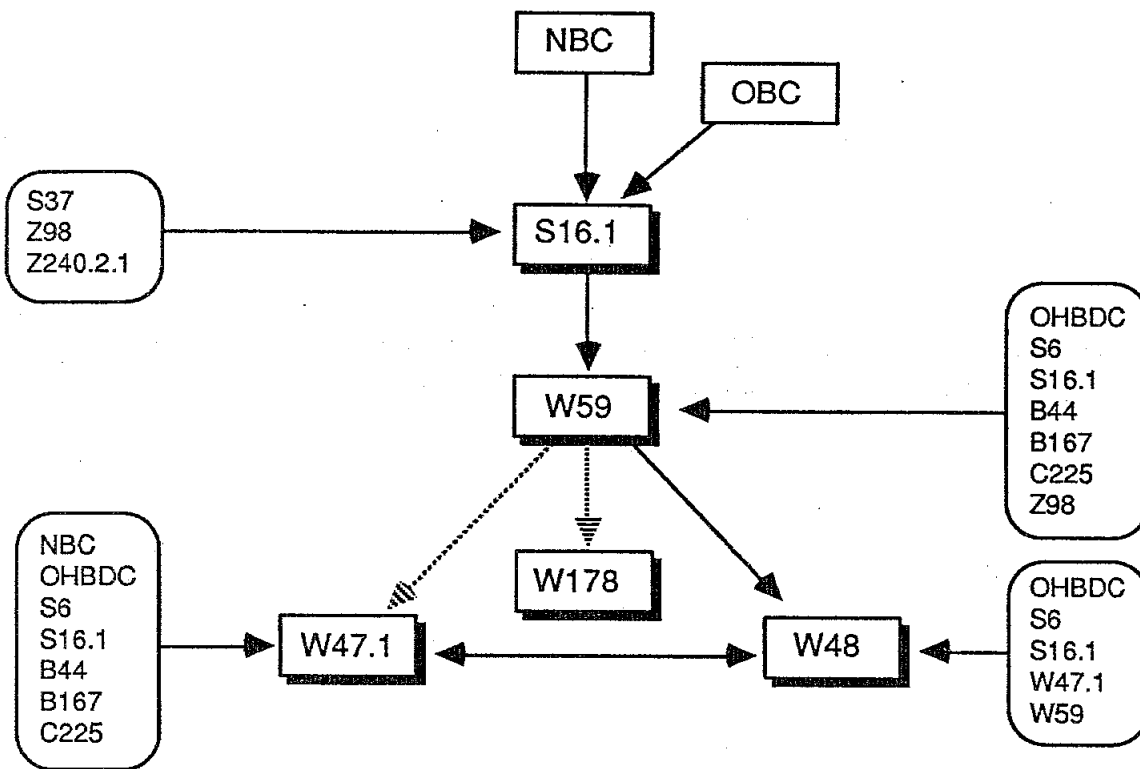
The reasonably uniform quality of welded structural fabrication across the country and the proven technological competency of the welding engineering and supervisory personnel of the fabricator demonstrated through the years can justifiably be credited to the W47.1 Standard.

As an unprecedented and convincing proof of its reputation almost all major governing design specifications make certification to the W47.1 Standard a mandatory requirement. (See figure on page 10)

This recognition is further evidenced by the fact that subsequent certification standards have been closely patterned on the framework of provisions of the W47.1 Standard. (See W47.2, W55.3, W178, W186).

In order to prevent any—not uncommon—misinterpretation of the intended objectives of the Standard the following must be clearly understood:

- (i) The W47.1 Standard is explicitly concerned with certification of companies. It is not a product standard and cannot be used to either evaluate or approve products. Consequently it is not intended to supersede or encroach on codes of other jurisdictions governing the manufacture of specific products such as pressure vessels (ASME, API, CSA B51.).
- (ii) Although the basic provisions of the code can be argued to indirectly constitute some measure of quality assurance, it must be stressed, that it remains the responsibility of the purchaser (owner) to ensure, through adequate inspection that the required quality of welded fabrication is attained.
- (iii) The need for such inspection programs is by no means to be dismissed or lessened by virtue of the Bureau's own periodic visits to the company, as their sole objective is to monitor each company's compliance with the conditions of the code.



Direct reference
to CSA welding
standards



CSA standards
with welding requirements



Non-mandatory reference

INDEX OF STANDARDS

NBC	National Building Code
OBC	Ontario Building Code
OHBDC	Ontario Highway Bridge Design Code
CSA Standards	
S16.1	Steel Structures for Buildings (LSD)
S37	Antenna Towers and Antenna Supporting Structures
Z240.2.1	Structural Requirements for Mobile Homes
W59	Welded Steel Construction (Arc Welding)
S6	Design of Highway Bridges
B44	Safety Code for Elevators, Dumb-waiters and Escalators
B167	General Purpose Electric Overhead Travelling Cranes
C225	Vehicle Mounted Aerial Devices
Z98	Aerial Passenger Tramways
W47.1	Certification of Companies for Fusion Welding of Steel Structures
W48	Electrode Standard Series
W178	Qualification Code for Welding Inspection Organizations

The uniqueness of the W47.1 qualification system lies in the certification of the company including specifically:

- (1) its designated engineering
 - (2) its designated supervisory
 - (3) its designated welding
- } personnel

in addition to

- (4) qualification of its welding procedures, and
- (5) documented affirmation of the availability of suitable welding and auxiliary equipment.

These five points define the fundamental conditions of certification to be met.

A few brief comments on the first two will help clarify the intent of two special provisions attached to them:

- (i) by insisting on Professional Association membership of the engineering personnel undertaking responsibility for welding, the Standard relies heavily on the code of ethics in their professional conduct in discharging these responsibilities.
- (ii) furthermore, by setting a definite minimum for welding education as well as prescribing a minimum measure of practical fabrication or welding experience for the engineering and supervisory personnel the code effectively ensures the well balanced and necessary level of their technological capability.

The Bureau as the implementing body was originally instrumental in the preparation of a number of correspondence courses as a resource material to assist these key personnel to successfully meet the specified educational requirements. Such effective assistance had a resounding positive influence on building a formidable welding background of the fabricator. Finer insight into welding associated phenomena, a more knowledgeable engineering control, and more effective and competent shop and field supervision—significant quality assurance factors of long standing—must be given credit for the increased production efficiency, more consistent good workmanship, and the resulting sizeable cost savings.

Several editions of the code have been published in the course of years (1947, 1973, 1983) to reflect not only the continuing advances in welding technology but also the experiences gained in its administration.

Review

The following are a number of special provisions characteristic of the W47.1 Standard:

- (1) The Standard provides for three divisions of certification:

- Division 1 - requiring *employed* engineering personnel to assume responsibility for welding design, and for welding procedures and practice,
- Division 2 - requiring *retained* engineering personnel to assume same responsibilities, and
- Division 3 - not requiring engineering personnel.

While no distinction is made in the educational and practical experience criteria for the engineering and supervisory personnel in Divisions 1 and 2, a reduction in the number of years of practical experience for supervisors in Division 3 is permitted.

W47.1-1983 (Certification of Companies for Fusion Welding of Steel Structures) includes

- Qualification of engineering and supervisory personnel
- Qualification of welding procedures
- Qualification of welders and welding operators
- Equipment
- Documentation

For greater convenience to the company provisions are included to allow the dual engineering responsibilities to be undertaken separately by two engineers.

Furthermore two subdivisions are recognized in Division 2:

Division 2.1 - in which both engineering responsibilities - design and practice must be undertaken, and

Division 2.2 - in which only the responsibility for welding practice needs to be assumed.

For the retained engineering personnel in Division 2 reports on its direction of the welding activities of the company are required. Their extent and frequency are left to the discretion of the Bureau.

(2) The procedures to be observed by the Bureau upon the receipt of an application and eventual granting of certification are well defined together with a clear sequence of steps involved in the decertification of a company. Should meeting of educational requirements cause a significant delay in certification, the Standard provides for a tentative approval of maximum duration of two years. Reference is also made to the mandatory publication by the Bureau at time intervals not exceeding one year of a list of fabricators certified in each of the three divisions.

(3) Next, details of information to be included in a company's application for certification are given. Among them are data of major importance, all necessary for the Bureau to initiate the certification program and conduct it with a minimum of potential delays. To these belong:

- the desired Division, in which certification is sought,
- list of engineering and supervisory personnel designated by management to assume pertinent responsibilities together with details of their education and experience,
- list of welding personnel and welding equipment,
- set of welding engineering standards, welding procedure specifications and related data sheets.

(4) The Standard outlines clearly the obligation of the company to advise the Bureau:

- of any changes in the engineering and supervisory personnel,
- of the need to submit any changes and revisions to welding procedure specifications and related data sheets, and
- of the number of employed welding personnel by means of periodic reports with their frequency left at the discretion of the Bureau.

The objective of these requirements can be said to be dictated by the Standard's concern that conditions of certification be effectively maintained.

(5) The educational requirements for the engineering personnel are separately defined for each of the two responsibilities involved: the welding design and the welding procedures and practice. These include the academic background and tangible evidence of additional courses of study involving examinations on a number of welding related areas specific to each of the two responsibilities.

- Educational resource material of acceptable level is referenced for convenience,
- Exemptions are permitted in special circumstances and knowledge of applicable welding standards is to be demonstrated,
- The educational requirements of the welding supervisors are presented in a similar manner.

It should be noted, however, that the educational requirements for both the engineering and supervisory personnel are related strictly to the operation of the company. If on one side they offer an important and immediate advantage in speeding up the certification, on the other side however, they prevent mobility as in each case of change of employment this change constitutes grounds for requalification of the same personnel.

(6) Special reference is made to the submission to the Bureau of:

- Welding Engineering Standards
- Welding Procedure Specifications
- Welding Procedure Data Sheets

While the first provide some degree of engineering guidance—more substantial in the case of a Division 1 fabricator—the other two, when approved by the Bureau, are the key documents controlling the soundness of the welding operations of the company. They must encompass all of the actual operations, and it is their enforcement by qualified and competent supervision that is the key to trouble-free fabrication enhancing production efficiency and ultimately the company's reputation.

(7) Extensive coverage of the welding procedure qualification system follows:

- a) In line with similar requirements in other CSA welding and design standards, the W47.1 code postulates that primarily only welding processes and electrodes certified to the pertinent standard of the CSA W48 series are eligible for inclusion in welding procedures.

However, for processes or electrodes not covered by the W48 standard series or covered, but as yet not certified by the Bureau, the W47.1 Standard offers their

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acceptance by means of procedure qualification but with a justifiably narrowed down validity of such qualification. This specific provision is intended to facilitate and encourage the fabricator to take full production advantage of new developments and innovative technology even in the face of the imposed limitations.

- b) Detailed listing of essential variables is provided in the Standard for the base metals and separately for each of the welding processes:

SMAW - shielded metal	}	arc welding processes
FCAW - flux cored		
GMAW - gas metal		
SAW - submerged		
ESW - electroslag	}	welding processes
EGW - electrogas		

Essential variables are those parameters of a welding procedure, a change in which is considered to adversely affect the properties and soundness of the welded joint. For that reason any change in parameters designated as essential variables constitutes grounds for a new qualification.

- c) The typical tests include a reduced section tensile test, bend tests (root, face, side) and macro-etch specimen, with radiographic and ultrasonic inspection allowed prior to the preparation of test coupons.

Impact and hardness tests are not required. They are designated as "supplemental" and guidance recommendations for them are included in the Appendix primarily to ensure uniformity of testing should they be specified by an outside authority.

- (8) A separate clause deals exclusively with qualification of welders and welding operators:

- a) The Standard makes it a special point to emphasize that the skill levels as reflected in the qualification requirements are considered sufficiently demanding to assess the capability of the welder to perform satisfactorily in production under the continuous and effective guidance and control of his performance by responsible, qualified supervision.
- b) Identification transfer cards are provided for welders and welding operators tested on standard assemblies allowing them free mobility of employment within other certified companies.

Although basically only welding personnel employed by the company can be tested by the Bureau, the Standard provides for testing of welders associated with unions and educational institutions when special arrangement agreeable to the Bureau can be made.

- c) In the area of qualification several conditions require separate testing. These conditions are:

- (i) mode of process application:
- *welder* test for manual and semi-automatic application,
 - *welding operators* test for machine and automatic application,

- (ii) type of test assembly involving:
 - welding from one side only *without* steel backing for "T" classification welders,
 - welding from one side *with* steel backing for "S" classification welders,
- (iii) type of welding process (see point 7(b)),
- (iv) position of welding (flat, horizontal, vertical, overhead),
- (v) in the case of the SMAW process the group designation of electrodes (F) governing the extent of validity in terms of electrode classifications.

Validity interrelation between "S" and "T" classification welders is established. It must be stressed that all qualifications must be witnessed by a Bureau representative.

- d) Validity of qualification is set for two years with provisions for check testing and upgrading tabulated. Conditions invalidating qualification are defined.
- e) ASME qualifications are recognized by the Standard as equivalent to its own within the applicable limitations, provided, that evidence is available attesting to the fact that the welder or welding operator has passed the ASME test:
 - (i) while in the employ of a certified fabricator, and
 - (ii) when duly witnessed by the certified inspector of the jurisdictive provincial government.
- f) Standard test assemblies for "T" classification welders involve pipe sections except for the vertical position test while plate assemblies are specified for the "S" classification welders.
- g) Testing involves bending of coupons (root, face, side) taken from designated locations in the test assembly. Radiography is permitted in lieu of mechanical testing except for the GMAW process, and acceptance criteria for the destructive and non-destructive tests are specified. Provisions for retesting are given.
- h) Special test provisions for tackers are included together with rules governing the production employment of "probationary" welders, that is, welders not having valid identification transfer cards or student and apprentice welders.
- i) Appendices show suggested forms for welding procedure specifications and welding procedure qualification test reports. They provide typical information to be listed in the welding procedure data sheets and include separate guidance recommendations for the supplemental impact and hardness tests.

47.1

CSA STANDARD W47.2

"CERTIFICATION OF COMPANIES FOR FUSION WELDING OF ALUMINUM"

Review

A new edition of this Standard is currently before committee in draft form and is expected to be published in 1986. The requirements of this Standard are closely patterned on those of its sister standard W47.1. For this reason only a brief review of its main provisions is considered necessary with special accent on the similarities and differences between them.

Similarities

The similarity between them extends to:

- (1) the concept of three divisions with the same distinguishing criteria applicable,
- (2) the certification and administration procedures to be followed by the Bureau with identical obligations on the part of the company for maintaining the condition of certification (reporting of changes in welding personnel and welding procedures),
- (3) the educational and practical experience requirements for the engineering and supervisory personnel in Divisions 1 and 2, but with the years of experience for the latter increased to 4 in case of Division 3,
- (4) the requirements related to Welding Engineering Standards, Welding Procedure Specification and Welding Procedure Data Sheets.

Differences

The following are the major differing provisions of the W47.2 Standard related primarily to extent of application and new gradation in welder or welding operator qualification:

- (1) the application of the Standard is restricted to:
 - (i) commercial fabrication of aluminum structures and their repair—specialized product fabrication totally excluded (pressure vessels),
 - (ii) thicknesses 3 mm and greater,
- (2) the welding processes are limited to include only:

GMAW - gas metal arc	}	welding processes
GTAW - gas tungsten arc		
PAW - plasma arc		
- (3) Essential variables related to each of the welding processes are listed and base metal alloy groupings as another variable clearly tabulated.
- (4) Welding Procedure Qualifications include plate and pipe test assemblies for groove welds and plate assemblies for fillet welds. In case of pipe assemblies a "6G" - (inclined 45° to the horizontal) non-rotating pipe has been introduced. A fracture test has been added to normal W47.1 procedural tests.

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- (5) The concept of performance levels has been introduced for welder qualification:

Level I -	designating fillet welding only,
Level II -	designating welding either from both sides or from one side with backing,
Level III -	designating welding from one side without backing for the full thickness of material,

- (6) In addition to the performance levels the qualification of welders and welding operators is governed by:

- the welding process,
- mode of process application (semi-automatic, automatic),
- type of weld and position, and
- the filler metal alloy group in the case of the GMAW process.

- (7) Pipe and plate test assemblies are provided for with a "fracture test" added to normal W47.1 tests.

- (8) While in W47.1 qualification for F, H, V, OH, was designated as for example "*class F*" qualification, the W47.2 Standard uses the term "*category F*".

CSA W55.3-1965

"RESISTANCE WELDING QUALIFICATION CODE FOR FABRICATORS OF STRUCTURAL MEMBERS USED IN BUILDINGS"

General

The use of resistance welding primarily in fabrication of open web steel joists prompted the preparation of the W55.3 Standard. Its main objectives are:

- (1) to define the minimum technological capability of the fabricator in terms of his personnel and facilities,
- (2) to determine the scope of welding procedures to be procured by the fabricator,
- (3) to provide for qualification of these procedures, and
- (4) to instigate a system of quality control in production deemed sufficient to ensure sustained and reliable execution of welding and hence safe performance of the structural element in service.

Review

The Standard refers in its scope to requirements for equipment, preparation, methods of weld process control, inspection, and testing of resistance welded elements or structural components designed to carry calculated loads (open web joists, open web rigid frames, roof and floor decking). A variety of profiles is recognized: rods, angles, tubes, sheets, together with applicability of the whole family of resistance welding processes such as the spot, seam, projection, and flash-butt welding processes (the last one for splicing of sections). The administration of the Standard is left with the Canadian Welding Bureau with requirements for the Bureau's periodic inspections and its authority to take remedial action, where the conditions of the Standard are not being fully met.

The framework of certification of the fabricator follows the pattern established by the W47.1 Standard and includes the requirements for:

- (1) duly qualified engineering personnel with evidence of competence required,
- (2) capable welding supervision with acceptable experience and demonstrated practical expertise,
- (3) resistance welding equipment of suitable capacity,
- (4) plant facilities with required testing equipment,
- (5) welding procedures defining schedules with details of machine set-ups and control settings for each production operation, and
- (6) established quality control system in conformance with specified requirements of the Standard.

Extensive testing at specified overloads is involved prior to approval of welding schedules. The type of tests and related testing equipment designed to measure the safe attainment of these overloads, although left at the discretion of the fabricator, must be to the satisfaction of the Bureau.

Codes and Standards

The quality control requirements involve:

- the routine check specimen - taken at specified instances and tested as either individual welded joints or complete assemblies with acceptance criteria stipulated for each option,
- provisions for permissible range of changes in control settings, and
- action in case of repair.

Schedules showing the frequency of changes of electrodes and of inspection of all equipment influencing the quality of welds have also to be approved by the Bureau. As customary the Bureau is under obligation to publish a list of fabricators certified to this Standard.

CSA STANDARD W59-1984 *READ*

"WELDED STEEL CONSTRUCTION - (METAL ARC WELDING)"

General

The CSA W59 Standard is judged to be the primary steel welding standard in Canada. As already pointed out it is directly linked with the CSA Standards W47.1 and the W48 Standard series dealing with certification of companies and filler metals respectively, and because of its stipulations involving the other two, may be considered greatly responsible for the resounding success of structural welding nationally.

In conjunction with the CSA W178 qualification codes for inspection organizations and individual inspectors there is in Canada an encompassing framework of standards and an extremely well integrated system of certification and qualifications all geared to provide a reliable measure of assurance of safe performance of welded structures in service and hence of public safety.

The 1984 editions of the Standard include:

- the sixth English version using *imperial* units,
- the first English version using *SI (metric)* units, and
- the first French version using *SI* units published under the title "Construction soudée en acier" (soudage à l'arc).

W59 Includes...

- Workmanship standards and technique
- Prequalified details of joints
- Inspection procedures and acceptance criteria
- Design strengths for welds for allowable stress and limit states design methods
- Allowable stress ranges for fatigue

It may be of interest to note that in the metric edition hard conversion has been used and the contention of the Committee is that in the case of any disputes with regard to numerical values the metric values should govern.

Such continuous updating is a commendable evidence that the Standard is keeping pace with the technological development in the area of welding processes and steel materials as well as the increasing production capability of modern industrial plants and the advancing welding engineering expertise of the fabricator.

It should be noted that the 1984 editions of the Standard maintain the concept of keeping the requirements common to all types of structures in clauses 1 to 10 while reserving:

- (i) Clause 11 for rules governing welding of statically loaded structures, and
- (ii) Clause 12 for rules governing welding of dynamically loaded structures.

It should be further noted that in these two clauses provisions are included for

- (i) the allowable stress design (ASD) method, and
- (ii) the limit states design (LSD) method.

This is in view of both methods being used in current engineering practice, although the phasing out of the ASD method in other governing CSA design standards (say S16.1) supports the expectation that the LSD design approach will eventually become the preferred approach.

Review

There is a number of provisions in the Standard of specific significance that either clearly define the extent of its coverage or that are mandated upon the designer, the fabricator, and the inspection agency. These are briefly discussed next, occasionally with explanatory background reasoning for their inclusion into the Standard where feasible or deemed necessary:

(1) Clear statement is made with respect to types of steel structures excluded from the coverage. Reference is made to the distinct requirements provided by other regulatory authorities exercising jurisdiction and having specific expertise pertinent to related, given products (eg., water pipes - American Water Works Association AWWA, pressure vessels - ASME, API).

(2) Applicable, included welding processes are those used in actual fabrication operations, the procedural requirements for which have been drawn from a pool of reliable and proven experience and acquired technological expertise. To these belong:

(1) Shielded Metal Arc	} Welding	- SMAW
(2) Flux Cored Arc		- FCAW
(3) Gas Metal Arc		- GMAW
(4) Submerged Arc		- SAW
(5) Electroslag		- ESW
(6) Electrogas		- EGW
(7) Stud		- ST

A further requirement of the Standard is that the filler metals (consumables) for each process be approved either in accordance with the provisions of the CSA W48 electrode standard series or when not applicable in accordance with the pertinent provisions of the CSA W47.1 Standard.

(3) Pre-approved materials, meaning those acceptable without reservation, are identified as steels, whose specified minimum yield strength does not exceed 700 MPa (100ksi). A comprehensive listing of the eligible steels together with their CSA or ASTM designations is provided.

(4) An important requirement of the Standard is directed towards the technological capability of the fabricator. It requires him

- to be either certified under the provisions of the CSA W47.1 Standard, or
- to demonstrate his competency to produce welded structures of desired quality and soundness to the Engineer, the professionally qualified designated representative of the regulatory authority or of the purchaser, as applicable.

Although this requirement appears optional, the fact is that in the case of almost all types of steel structures it can be said to be mandatory by virtue of other, governing design standards demanding certification to the W47.1 code. As a matter of fact, imposed on this fundamental requirement is the additional stipulation in the CSA S16.1 Standard "Steel Structures for Buildings" that only fabricators certified in Divisions 1 and 2 under the CSA W47.1 code are eligible to undertake work on any steel structures the design of which is governed by S16.1.

(5) With respect to inspection the Standard stipulates that preferably organizations certified to CSA W178 "Qualification Code for Welding Inspection Organizations" be used. The non-mandatory certification to W47.1 (point 4) and to W178 (point 5) was prompted by "no trade restriction" considerations.

(6) Clear definitions of the fundamental concepts inherent in strength calculations of welded joints and connections are provided. These concepts are of basic importance in assessing the capacity (ASD) or the resistance (LSD) of welds for which pertinent formulae are tabulated in clauses 11 and 12 and they involve:

- types of welds, types of groove welds,
- their minimum and effective sizes together with separate provisions for fillet welds, plug and slot welds.

(7) Extensive requirements governing the workmanship and welding technique of the fabricator are included. To these belong:

- conditions for matching of filler-base materials for welding of corrosion resistant steels,
- maximum exposure times and subsequently storage and conditioning of electrodes especially those of the basic type with due recognition of the merits of special electrode dispensers, for which however a demonstration of acceptable performance measured by amounts of diffusible hydrogen in weld metal is required,
- specified limits of acceptability of planar discontinuities in base material and recommended action for repair of edge discontinuities with clear distinction made in terms of type and extent of inspection related to significance of stress and type of load application,
- state and preparation of material for welding with tolerance limits for assembly and fit-up of structural elements,
- workmanship tolerances for the preparation and fit-up of groove welded joints,
- provisions for:
 - i) tack welds - taking into account their possible remelting,
 - ii) temporary welds - defining the procedural conditions for their removal, their quality with due recognition of their severity under contemplated service conditions,
 - iii) seal welds - stipulating conditions permitting their use and requiring particular attention on the part of the Engineer and the fabricator. The objective of these provisions for such welds—relegated to a simple sealing function—is to minimize their potential of becoming a source of problems in service.

Codes and Standards

- details of welding procedures and techniques for each welding process representing sound and service performance proven practices with definite requirements with respect to material for:
 - run-off plates and extension bars to ensure sound termination of groove welds,
 - backing bars, into which thorough fusion is required,
- extensive treatment of stud welding including:
 - requirements for base qualifications by manufacturer,
 - stud material,
 - workmanship with detailed procedural control requirements with distinction between shear and other types of studs,
- recommended sequences in assembly and welding aiming at minimizing distortion and residual stresses. Reducing distortion has strong cost saving connotations while lowering residual stresses, especially those tensile in nature, would be expected to improve service performance under certain types of load and environmental service conditions.
- preheat and interpass temperatures as tabulated are related to steel designations (indirectly to Carbon Equivalent - expressing their weldability), thickness of material and basic or non-basic nature of electrodes or processes. Heat input by arc, dissipation of heat, actual carbon equivalent and restraint are unfortunately not considered, although action to include these parameters and modernize the approach to preheat is pending.
- conditions permitting reduction of preheat temperatures are identified for minimum single pass SAW fillet sizes based on test results yielding acceptable hardnesses in Heat Affected Zones (HAZ).
- dimensional tolerances for finished welded structural elements. These tolerances are judged not to adversely affect their performance in service.
- acceptable profiles of fillet and groove welds. These limitations are governed by the intent to minimize stress concentrations due to notch effects and at the same time are considered reasonably achievable in fabrication.
- corrective action for defective welds. This action varies with the type of defect from removal of weld (excessive convexity), depositing additional weld (excessive concavity, crater, undercut), removal and rewelding (excessive porosity, slag inclusions, incomplete fusion).
- requirements for stress relief, when specified. These refer to temperature, holding time, rates of heating and cooling.

(8) With respect to welding inspection:

- advanced communications between the inspection organizations and the fabricator as well as timely scheduling of inspection is emphasized,
- obligations of the fabricator on matters arising from results of inspection are clearly stated,
- conformance of nondestructive (NDT) procedures to pertinent clauses of the Standard and applicable ASTM codes are called for.

(9) For cases of repair and strengthening the importance of prior investigative action is stressed with particular emphasis on the designer - fabricator dialogue, so that any repair or strengthening may have the full support of sound engineering decisions.

(10) The concept of "prequalification" introduced in previous editions is continued. It applies only to SMAW (shielded metal arc), FCAW (flux cored arc) and SAW (submerged arc) welding processes. While for SMAW all positions of welding are eligible, the prequalified use of FCAW in groove welds is permitted only for horizontal and flat and that of the SAW only in flat position.

(11) As already pointed out clause 11 includes all design and construction provisions for statically loaded structures, principally buildings. Clause 12 instead covers exclusively the requirements for dynamically loaded structures with particular emphasis on fatigue, the inherent mode of behaviour under fluctuating loads typical of bridges and crane runways. It should be noted that the arrangement and sequence of clauses has intentionally been kept parallel in both sections for greater convenience and ease of use.

The extensive design coverage in both clauses includes:

- a) tabulated strength matching of "base metal-electrode classifications" with seven steel groupings identified by stepped increases in their minimum specified ultimate strength with correspondingly aligned electrode classifications. However, the individual steel designations in each steel groupings in clause 12 are more restrictive. Such finer selection of steels was dictated by considerations of better weldability and desired notch toughness capability.
- b) tabulation of allowable stresses (ASD method) and factored resistances (LSD method) of welds as function of types of welds (groove, fillet or plug) and type of stress (tension, compression, shear) with formulae defining their capacities (ASD) and their resistances (LSD). However, in the clause 12 tabulation tension normal to the axis of the weld for partial penetration groove welds and the use of plug welds are not permitted. The extent of non-matching is also shown and is the same in both clauses. A footnote common to the tabulations in both clauses rules that only 0.9 of the fillet weld capacities or resistances as listed be used for application to design of railway bridges.
- c) the fatigue design provisions of clause 12—considered applicable for number of load cycles (N) exceeding 10,000 and only for tension and stress reversal—include specifically:
 - (i) the concept of "stress ranges", of which seven are provided (A to F and W - for weld metal) and which are a function of four different numbers of cycles (N) - namely: 100,000; 500,000; 2,000,000; and over 2,000,000 cycles,
 - (ii) separate tabulation describing a number of common types of structural details each identified by "S" - number—and illustrated in a figure—and each assigned a specific stress range category.

The remainder of the provisions in both clauses 11 and 12 cover rules pertaining to structural details, such as

- transition in splices in case of differential thickness or width of the material,
- minimum required splice capacities for tension and compression,
- extent of welding on components of built-up members.

Specific tolerances are given for structural members and the acceptable quality of welds are defined both being more demanding in clause 12. The acceptance criteria are also more explicit in the same clause.

(12) Several appendices are included in the Standard. They are non-mandatory, except when otherwise specified, as is the case of Appendix "H" on "Material and Stud Base Qualification Requirements, Inspection Recommendations". They provide either background information, terms and definitions or tabulations intended to assist the fabricator or the designer.

CSA W117.2-1974 DONT BOTNER

"CODE FOR SAFETY IN WELDING AND CUTTING (REQUIREMENTS FOR WELDING OPERATORS)"

Review

The CSA W117.2 Standard, although the first one published, is the second part of the intended twin set of standards, the other being the CSA W117.1 "Code for Safety in Welding and Cutting" (Equipment and Installation Requirements) left for later publication.

The main objective of the W117.2 Standard is the protection of people from injury and illness and the protection of property from damage by fire and other causes arising from welding and cutting equipment, its operation and maintenance.

Although its provisions are meant to be applicable to a wide range of welding processes, some selected, more common processes are given separate attention.

An extensive coverage of safe installation, operation, and maintenance of arc welding and cutting equipment aims at greater awareness of hazards and potential dangers on the part of operating personnel. Full consideration is given to several phenomena associated with welding and inherently dangerous to human health with protective measures stipulated.

Equally extensive attention is given to safe operating rules for oxygen-fuel gas systems for welding and cutting with emphasis on proper storage of cylinders and containers, their handling, and especially their safe production use.

Finally with respect to personnel, a number of protective measures are specified, with specific reference to eye and clothing protection, precautionary steps prior to welding in confined spaces, fire prevention and protection. The importance of ventilation is duly recognized and detailed procedural recommendations provided as a function of the toxic significance of materials.

CSA STANDARD W178-1973

READ

"QUALIFICATION CODE FOR WELDING INSPECTION ORGANIZATIONS"

General

The W178 Standard uses the qualification concept of the W47.1 Standard and hence encompasses the full organization or its respective division performing welding inspection. As a national standard administered by the Canadian Welding Bureau it serves to ensure uniform and reliable inspection capabilities of companies engaged in quality control of welded structures.

In view of the growing national and international appreciation of quality in the manufacturing process the competency of inspection services assumes ever increasing importance. Design sophistication and related more advanced exploration of material capabilities further substantiate this importance.

The W178 Standard, although clearly written for certification of outside inspection organizations, does not preclude its application to the manufacturer's or fabricator's own inspection systems. Its main objective is to set basic requirements for obtaining and maintaining certification in any of the clearly identified inspection service categories.

Review

The administration provisions define the responsibilities as well as the extent of authority of the Bureau at the time of granting of certification and during the subsequent surveillance of the company's adherence to the conditions of certification.

Included are provisions for specific cases where retention by contract of qualified personnel and equipment is necessary for a given company to fully meet the requirements of the Standard. Clear reference is also made to the Bureau's obligation to publish periodically lists of certified companies. On the other hand the companies are required to immediately report any changes in personnel and equipment.

Eleven separate categories in which to seek certification are provided for selection by the companies. These relate to distinctive product or family of products oriented fabrication.

The specific requirements for certification include the following:

- (1) standard inspection procedures providing clear instructions with respect to execution of the basic and most common inspection functions like checking the qualifications of welding personnel, availability of approved welding procedures, identification of base and filler materials, extent of inspection prior to welding, during welding together with acceptance inspection and preparation of reports,
- (2) standard testing procedures covering all destructive and non-destructive methods contemplated for use by the company,
- (3) inspection personnel meeting the qualification requirements of the Standard,

(4) suitable inspection equipment and test facilities.

The Standard distinguishes between the following three levels of inspection personnel:

- certified welding division supervisors,
- certified welding inspectors, and
- qualified operators for test facilities and equipment.

It sets specific educational, training, and experience criteria for each level. Mobility of qualified personnel within certified companies is permitted.

In the case of radiographic and ultrasonic inspection methods anticipated for use in service by the company certification as senior industrial radiographers and senior ultrasonic operators in accordance with the respective Canadian General Standards Board (CGSB) specification is required.

The very demanding educational requirements for the division supervisor extend to his knowledge of principles and application of welding processes, his thorough understanding of inspection methods, weld discontinuities and the applicable welding codes and standards. He may be required to demonstrate his knowledge by means of examinations. Reference is made to acceptable courses of study upon successful completion of which the foregoing requirements may be partly reduced.

With respect to the second personnel level, separate provisions are made for junior and senior welding inspectors with the first ones free to perform routine inspection but under the supervision of the responsible senior personnel. Obviously less demanding educational requirements are set for the junior inspector level with some knowledge related to welding and inspection to be demonstrated. In addition specified years of practical welding fabrication experience in certain capacities are demanded.

In the case of senior inspectors the Standard stipulates more advanced educational welding background and extends it to proven ability to interpret drawings and inspection results, to understand governing codes, and to acceptable familiarity with the qualification system of welders and welding procedures. A longer period of practical welding fabrication or welding inspection is also stipulated.

These superior qualification requirements for the senior key inspection personnel are thought to add markedly to their capability to properly discharge their inspection responsibilities.

With respect to operators of other testing equipment like that for the Magnetic Particle or Liquid Penetrant methods certification to pertinent CGSB specifications is required while in the case of other equipment the qualification is left at the discretion of the Bureau.

CSA W178.2-1982

THIS GOVERNS WHAT WE WILL
BE DOING.

"CERTIFICATION OF WELDING INSPECTORS"

General

The direct objective of the W178.2 Standard—published first in 1982—is to provide further assistance in the industry's efforts to produce quality products by making available to it welding inspection personnel certified individually as to its skill and capability.

Effectively supporting this primary objective is the fact that the prospective applicants need not be members of an inspection organization. This adds a good measure of flexibility to the setting of the manufacturer's own optimum quality programs.

Recognizing the fact that the integrity of inspection is largely dependent on the theoretical knowledge and practical experience on part of those performing it, the W178.2 Standard establishes appropriate educational and experience criteria considered adequate to ensure the required level of inspection competence. In its scope it also logically provides a link with the W178 Standard.

The administration of the Standard is entrusted with the Canadian Welding Bureau relying on its best professional judgement in the implementation of all those provisions, where such judgement is necessary. Although not explicitly required by the Standard, the Bureau issues a list of certified welding inspectors at time intervals left at its discretion.

Review

The Standard sets certification requirements for three levels of inspector personnel, levels 1, 2 and 3 in an ascending order of competence with some provisions for trainees. It defines the responsibilities together with the related competency requirements for each inspector level. In the case of radiographic, ultrasonic, magnetic particle, and liquid penetrant inspection methods certification to appropriate Canadian General Standards Board (CGSB) specifications is mandatory.

Experience in welded fabrication or welding inspection in one or more capacities of several listed for each area, is required. The years of experience increasing with each level are directly related to educational requirements in a manner that allows for reduction in time with more advanced and substantial educational background.

In addition to practical tests on visual detection and identification of faults open book examinations are specified on inspection standards for any category of products (10 listed) for which certification is sought. Closed book examinations involve welding, inspection, and metallurgy with the required extent of knowledge duly apportioned for each level.

Of importance is to note that suitable recognition is given to inspection personnel employed by companies certified under the W178 Standard. Certification in level 2 is granted to inspectors qualified by the American Welding Society when certain conditions are met, and AWS provides reciprocal recognition.

Codes and Standards

Submission of evidence of satisfactory vision is required. Extent of validity is set for 2 years with procedures for renewal fully described.

Finally, the code of ethics is invoked to further stress the importance that the Standard attaches to the integrity of welding inspection.

CSA STANDARD W186-M1981

DONT BOTHER

"WELDING OF REINFORCING BARS IN REINFORCED CONCRETE CONSTRUCTION"

General

It should be first stressed that the W186 Standard is primarily a combined welding design and certification standard, which in addition prescribes workmanship and inspection requirements.

Its scope of application expressed in terms of welding is precisely defined by types of joints and connections, types of welding processes, and types of base materials.

Review

With respect to joints and connections it covers welding of reinforcing bars either directly to one another or through splice members or to structural steel members used in anchorages in pre-cast or cast-in-place concrete construction.

The accepted welding processes include the:

- shielded metal arc - SMAW
- gas metal arc - GMAW
- flux cored arc - FCAW



welding processes

together with:

- pressure gas
- thermit



welding

In case of the first three, emphasis is put on basic or controlled hydrogen electrode classifications. All electrodes for these processes are required to be certified to the pertinent standards of the CSA W48 series while filler metals for the last two processes are subject to procedure qualification as prescribed in the Standard.

Base materials are identified by referencing pertinent reinforcing steels of the CSA G30 Standard series while a number of structural steels are listed either under their CSA G40.21 or ASTM designations.

The administration of the Standard and specifically of its certification program is left with the Canadian Welding Bureau with the usual requirements for the Bureau to check on the maintenance of code conditions and to publish lists of certified fabricators.

The extremely detailed and comprehensive design provisions of the Standard are based on the limit states (LSD) principles with the SI (metric) units used throughout. Described are types of bar splices, types of bar to structural steel anchorage connections together with types of welds used (grooves and fillets). Special attention is given to flare grooves (welds between two round bars in a longitudinal lap joint and welds between a round bar and flat plate also in a lap joint). The effective sizes and lengths of all types of welds are established.

The minimum factored resistances of joints are defined and a number of formulae delivering these resistances provided. Included are also formulae precluding any other predictable or possible modes of failure associated with a given joint situation.

A comprehensive tabulation of design applications relating bar or plate material to electrode classifications for all possible types of welds is conveniently provided.

The provisions for workmanship are based on principles of good welding practice. Low temperature limitations for welding, preparation, and assembly requirements and the mandatory use of approved welding procedures with emphasis on proper application of preheat are clearly specified. Options for welding of galvanized steel are offered. Storage and conditioning of electrodes is covered in detail and the required quality of welds laid down.

In its part on certification the Standard has adopted identical requirements to those in the W47.1 Standard. They include:

- (1) qualified
 - engineering personnel, employed or retained,
 - supervisory personnel,
 - welding personnel,
- (2) approved welding procedures,
- (3) adequate welding equipment.

However, of great significance is the fact that fabricators already certified in Divisions 1 or 2 of the CSA W47.1 Standard are accepted as certified under the W186 Standard with only a few additional requirements related mainly to welding procedure qualifications and welder qualification for flare groove welding.

Conditions attached to the qualification of the engineering and supervisory personnel include educational and practical experience requirements. However, in each case as already stated, pertinent qualification under W47.1 is given almost full recognition under this Standard.

Welding procedure qualifications are covered with appropriate number of test assemblies provided and types of tests together with test results specified.

Qualification of welders is given similar comprehensive coverage with validity extended to two years. Qualification on flare grooves is taken as acceptable for fillet welds while fillet qualifications under the W47.1 Standard are also considered valid.

For other than visual inspection the Standard requires the use of organizations certified to the CSA W178 Standard.

In one of the appendices an exhaustive number of typical design solutions is provided for effective guidance of the designer. All classical types of joints and welds are used to illustrate the calculation procedure envisaged by the Standard.

CSA B51-M1981

ADOPTS ASME CODES + STAND.

"CODE FOR THE CONSTRUCTION AND INSPECTION OF BOILERS AND PRESSURE VESSELS"

This Code covers the design, construction, installation, operation, repair, and quality control of boilers, pressure vessels, and fittings. However, its preface states clearly that it is only a recommended standard unless officially adopted by various provinces.

In view of the fact that it is the provincial governments that assume full jurisdiction over the whole area of boilers and pressure vessels under their own Boiler and Pressure Vessel Acts, the B51 standard or some of its selected provisions are basically used to supplement in varying degrees the principal requirements of these Acts.

In the case of Ontario, it is the Boiler and Pressure Vessel Act of Ontario, as administered by the Pressure Vessel Safety Branch of the Ministry of Consumer and Commercial Relations (MCCR) that governs the total area involving these products. Pertinent governmental agencies of other provinces assume similar responsibilities.

However, it can be said that the B51 requirements for procedure and performance qualifications to conform to those of Section IX of the ASME Boiler and Pressure Vessel Code remain applicable but the extent of validity of performance qualifications, left to the discretionary powers of the regulatory authorities, may vary across provinces.

The quality control programs required by B51 in manufacture and repair of vessels may be subject to further tightening and refinement by the same authorities.

Other Canadian Standards

NATIONAL BUILDING CODE OF CANADA

The National Building Code of Canada is published by the National Research Council. Written by its Associate Committee on the National Building Code it comprises nine parts intended to serve as models of technical requirements with respect to public safety in buildings suitable for adoption by appropriate legislative authorities in Canada.

It has been used as the basis for provincial building codes. However, it has found wider application as municipal bylaws.

In its subsection on steel in Part 4 "Structural Design" it requires buildings and their structural members to conform to CSA Standard S16 "Steel Structures for Buildings" or CAN3-S16.1 "Structural Steel for Buildings - Limit States Design".

Furthermore in its Appendix "A" reference it identifies the specific clauses in both CSA S16 Standards, which require certification of fabricators and erectors of welded structural steel for the arc welding (W47.1) and resistance welding processes (W55.3) (Clause 23.3 in S16.1 - Clause 27.3 in S16).

CSA STANDARD S6-1974

"DESIGN OF HIGHWAY BRIDGES"

A comprehensive design standard encompassing all essential engineering considerations with separate coverage requirements for steel, reinforced and prestressed concrete, and timber. In its steel section a separate clause on "welds":

- invokes the provisions of the CSA Standard W59 "Welded Steel Construction,"
- reserves fabrication only for companies certified to CSA Standard W47.1 "Certification of Companies for Fusion Welding of Steel Structures," and
- requires inspection to be performed by either the designer or organizations certified to CSA Standard W178 "Qualification Code for Welding Inspection Organizations."

Although the mandatory use of electrodes certified to the CSA W48 Standard series is inherent in the W59 and the W47.1 Standards, the S6 Standard calls for their certification separately for greater emphasis.

CSA CAN3-S16.1-M

"STEEL STRUCTURES FOR BUILDINGS (LIMIT STATES DESIGN)"

The third edition of this most prestigious Canadian limit states design (LSD) standard for steel structures in buildings written in SI (metric) units is based on the first LSD edition of 1974 prepared in imperial units. The important fact associated with its 1984 publication is that the 1969 Standard based on the working stress design method has been officially withdrawn.

It should also be noted that this National Standard of Canada has been adopted by the National Building Code as a reference standard for steel structures, thus further reflecting its dominant position among the governing Canadian design standards.

Its wide scope covers rules and requirements for design, fabrication, and erection of steel structures for buildings with considerable attention given to joining and fastening material such as welds and bolts. Although its primary attention is directed to statically loaded structures it includes provisions for the design of fatigue loaded structures. Since the latter provisions appear in a number of other CSA standards (W59, S6) it is of importance to note that through a concerted and co-ordinated inter-committee effort these provisions have been kept identical in all pertinent standards.

The comprehensive design requirements of the Standard are said to incorporate the latest research recommendations and the continually advancing understanding of the behaviour of structures, their elements, and materials.

After an explicit coverage of drawings and materials (base metals, bolts, and electrodes) it deals most comprehensively with all fundamental considerations requiring design attention and continues further with treatment of resistances of members and connections under any external loading conditions.

In terms of headings, exhaustive design coverage is given to beams and girders, open web steel joists, composite beams and columns, built-up members, and connections involving welds and bolts with good practice requirements for the latter.

With respect to welding, reference is made to the CSA Standards W59 and W55.3 for design and practice in arc welding and resistance welding respectively, while for the same types of welding processes certification of fabricators is required either to the CSA W47.1 (Division 1 and 2 for primary contractors) or the CSA W55.3 Standards.

Finally, workmanship requirements including fabrication tolerances are specified and erection and inspection directives given.

In a number of appendices either explanatory background or detailed information of either supportive or complementary nature is provided.

This Canadian CSA Standard, because of its leading steel design expertise, is greatly renowned internationally.

CSA STANDARD S136-1984

"COLD FORMED STEEL STRUCTURAL MEMBERS"

This is primarily a design standard for structural members fabricated by cold forming of carbon and low alloy sheet, strip, or plate for which either welding, bolting, or other joining methods are used. Its design section is based exclusively on Limit State Design principles for use with SI (metric) units.

Besides the strict design provision the Standard covers:

- testing of material especially after cold forming to determine its modified mechanical properties and residual ductility,
- assembly including customary fabrication operations,
- erection with caution stressed in handling and avoidance of excessive temporary loads, and
- protection measures against corrosion.

In a separate clause on "Connections" reference is made

- for fusion welding of applicable thicknesses to conform to CSA Standard W59, and
- for resistance welds to conform to CSA Standard W55.2 "Resistance Welding Practice" (currently defunct).

CSA W48

ELECTRODE STANDARD SERIES

As noted previously the CSA W48 Electrode Standards are companions to the W59 and W47.1 Standards. This "trinity" of CSA standards can be said to have jointly laid down the solid foundations for structural welding in Canada.

The individual standards within the W48 series are as follows:

- | | |
|------------------|--|
| 1) W48.1-M1980 - | Mild Steel Covered Arc Welding Electrodes, |
| 2) W48.2-M1980 - | Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes, |
| 3) W48.3-M1982 - | Low-Alloy Steel Covered Arc Welding Electrodes, |
| 4) W48.4-M1980 - | Solid Mild Steel Filler Metals for Gas Shielded Arc Welding, |
| 5) W48.5-M1982 - | Mild Steel Electrodes for Flux Cored Arc Welding, |
| 6) W48.6-M1980 - | Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding, |
| 7) W48.7-M1977 - | Diffusible Hydrogen in Mild Steel and Low-Alloy Steel Metals; Test Method. |

Each of the first six Standards prescribes certification requirements for electrodes for the given individual welding process while the last one defines the method of establishing levels of

diffusible hydrogen in weld metal (glycerine method).

The administration of the Standards is left with the Canadian Welding Bureau, which is under obligation to publish lists of certified electrodes at yearly intervals.

Types and number of tests together with acceptable test results are specified. Check testing and relation to certification by other authorities are also defined.

The objective of the certification under the CSA W48 Standard series is to demonstrate the properties of weld metal *deposited* in a standard joint under specified and controlled welding conditions. It should be understood that these properties may differ with procedures used in production.

In view of the extensive coverage of "Electrodes and Consumables" in Module 6 including the discussion of the CSA W48 Standards, no further coverage in this module is thought necessary.

CSA Z183-M1982 "OIL PIPELINE TRANSPORTATION SYSTEMS" **CSA Z184-M1983 "GAS PIPELINE SYSTEMS"**

The intent of these two CSA Standards is to establish essential requirements and minimum standards for design, installation, and operation of pipeline systems for oil and gas respectively. Both are published in SI (metric) units.

Their all encompassing scope includes an extensive coverage of welding. The Standards stipulate their own welding procedure and welder qualifications together with details of essential variables, test assemblies, preparation of test specimens, and criteria of acceptance.

Arc welding and oxyacetylene welding processes are permitted under the Standards, with shielded metal arc welding (SMAW) electrodes requiring certification by the Canadian Welding Bureau to the CSA Standards W48.1 and W48.3.

Ontario Highway Bridge Design Code

Reference must be made to the Ontario Highway Bridge Design Code published by the Ministry of Transportation and Communication (MTC) and implemented by it for all highway bridges under its jurisdiction since 1979. Highway bridges under the jurisdiction of Ontario municipalities may use it at their discretion. Its design provisions are based on the limit states principles.

With respect to welding two sections deserve special mention:

- Section 10 "Structural Steel" stipulates:
 - a) electrodes to be certified to CSA W48 Standard series,
 - b) welding design and practice to conform to requirements of the CSA W59 Standard,
 - c) fabricators and erectors to be certified in Division 1 or 2 of the CSA W47.1 Standard.

module 13

CODES AND STANDARDS

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- Section 11 "Structural Fatigue" provides:
 - a) fatigue design requirements *identical* to those in CSA W59 and CSA S6,
 - b) a comprehensive fracture control plan (FCP) in which fracture critical and primary tension members are given very thorough coverage with respect to relative toughness requirements for base and filler metals and procedural requirements in case of repairs by welding.

It should be noted that other provinces design their bridges either in accordance with provision of CSA S6 or the code of the American Association of State Highway and Transportation Officials (AASHTO).

Ontario Building Code

The other impressive Ontario Government legislation is "The Building Code Act 1974" published in 1975. Its extensive provisions are aimed at regulation of the whole compound area of building construction.

In its Part 4 on "Design" the code requires the building and its structural members to conform to:

- CSA S16.1 - when made of structural steels, and
- CSA S136 - when made of light gauge steels.

By referencing S16.1 the code indirectly invokes the welding design provisions of the CSA W59 Standard.

Material Standards

The CSA Standard system on materials used in welded steel construction provides separate coverage of:

- base materials in the CSA G30 reinforcing steel series for reinforced concrete construction, and the CSA G40 structural steel series for steel construction,
- welding filler materials in the CSA W48 Standard series on electrodes.

With the latter discussed elsewhere it is the predominance of structural steels in welded construction that favours a more detailed discussion of the G40 series.

G40.20-M81 "GENERAL REQUIREMENTS FOR ROLLED OR WELDED STRUCTURAL QUALITY STEEL"

The G40.20 Standard covers the common requirements applicable to structural quality steel plates, shapes, hollow sections, and bars conforming to the provisions of the G40.21 Standard. It includes provisions for chemical analysis, mechanical testing, heat treatment, action in case of repairs, including repairs by welding for which documented procedures are mandatory.

It further stipulates that welded shapes can be produced by any producer certified under the CSA

Codes and Standards

W47.1 Standard. The "filler/base" material relation is specified to be in accordance with the requirements of the CSA W59 Standard. The strength of web-to-flange welds is defined and their quality stipulated to meet the W59 requirements.

Quality control tests are described with certificates reporting results to be available upon request.

CSA G40.21-M81 "STRUCTURAL QUALITY STEELS"

This Standard, written in SI (metric) units covers six types of structural quality steel plates, shapes, and bars. Each type given a distinctive letter designation has its own special characteristics designed for a certain specific application, be it in low temperature or corrosive environments with due consideration of suitability for welding. Mechanical properties are tabulated for each type and grade. A wide range of impact properties may be specified by the purchaser with Charpy-V values set for a number of given "thickness of material/test temperature" relationships for both the "as-rolled" and normalized conditions.

This Standard can be said to have employed one of the most advanced concepts in its unique system permitting it to comprehensively cover a wide variety of steels, for which previously separate standards were provided.

STANDARDS IN THE USA

American National Standards Institute - ANSI

Any objective and meaningful review of the American welding related standards system demands that the specific role of ANSI in that system be clearly defined. In general terms it can be said that it fulfills a somewhat similar function to that of the Standards Council of Canada.

The American National Standards Institute is the principal co-ordinator of voluntary standards activities in the United States and the agency that approves standards as American National Standards. In addition it acts also as a co-ordinator and manager of US participation in the work of non-governmental international standards organizations. It is clearly not a standards developing body.

ANSI is a privately funded non-profit organization. It was founded in 1918 as a result of economic drawbacks arising from the lack of national recognition of standards and from their unco-ordinated formulation. ANSI's constitution states clearly the criteria that govern the preparation of standards and the conditions to be met for their recognition and approval as American National Standards. Furthermore, it has developed an accreditation program for standards writing organizations which, when fully meeting the prescribed requirements, can have their standards approved as ANSI standards.

The term "standards" is to be taken as a generic term encompassing codes, specifications, recommended practices, methods, and classifications.

ANSI's prerequisites for an acceptance of a standard as an ANSI standard focus on balance, consensus, and review.

Balance refers to proportionate representation within the membership of a committee of diversified interest groups—suppliers, consumers, and general interest people—so as to ensure reasonably objective and unbiased collective decisions.

Consensus is not meant to imply unanimity, but a responsible, in-depth exploration of issues and a demonstrated accommodation of divergent views and opinions leading eventually to an acceptable compromise.

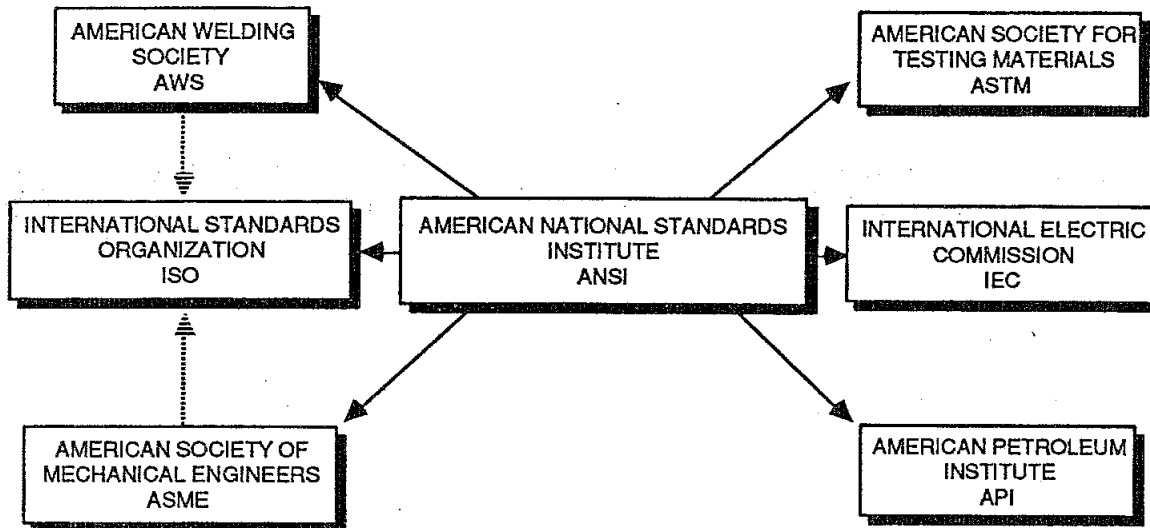
Review is the third of ANSI's guide rules. It calls for an adequate and independent review and for an appropriate appeal mechanism, should unfairness be claimed.

It is of interest to note that over 8500 ANSI approved standards have appeared in publication.

As stated previously ANSI is a co-ordinator of US participation in major non-governmental international standards bodies, namely the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC) and in this capacity is able to represent the

interest of US industry and business and hence influence the content of international standards that affect trade.

The following figure shows the interrelation in the US standards system.



US Standards Developing Organizations

When looking at the US standards system one is duty bound to discuss, however briefly, these major standards developing organizations, which in the course of years have successfully shaped the technological growth of national industry and left an indelible imprint on the economy, safety, and integrity of its output.

Entrenched in American life they can justly claim national and wide international recognition. Amongst them are:

- The American Welding Society - AWS
- The American Society of Mechanical Engineers - ASME
- The American Petroleum Institute, and - API
- The American Society for Testing and Materials - ASTM

The main thrust and objectives of each of them will be discussed and while the standards coverage for most will be rather general, some of the AWS specifications, because of their greater relevance, will be given individual attention.

American Welding Society (AWS)

The wide recognition that the American Welding Society has earned in the course of years nationally and internationally stems greatly from its distinctive and significant contribution to the transfer of welding technology, a service that is most essential to research,

development, application engineering, as well as to the manufacturers and users.

One of the means most successfully proven in that transfer is the Society's outstanding record of continual input into the formulation of standards. As an accredited standards-developing organization under ANSI guidelines the AWS can publish, within the prescribed rules, American National Standards pertaining to welding.

Balanced representation on committees is strictly enforced and a two level review is provided: one - by the Technical Activities Committee (TAC) for technical content and adherence to rules of operation; and two - by the Technical Council for publication.

There are 22 technical AWS committees responsible for more than 100 standards covering a wide range of areas related to welding. These committees are listed below:

AWS Technical Committees

Fundamentals

- A1—Metric Practice
- A2—Definitions and Symbols
- A5—Filler Metal

Inspection and Qualification

- B1—Methods of Inspection
- B2—Welding Qualification
- B4—Mechanical Testing of Welds

Processes

- C1/WRC—Resistance Welding
- C2—Thermal Spraying
- C3—Brazing and Soldering
- C4—Oxyfuel Gas Welding and Cutting
- C5—Arc Welding and Cutting
- C6—Friction Welding
- C7—High Energy Beam Welding and Cutting

Applications

- D1—Structural Welding
- D3—Welding in Marine Construction
- D5/AWWA/WEWWA—Watertanks
- D8/SAE—Automotive Welding
- D9 —Sheet Metal
- D10—Piping and Tubing
- D11—Welding Iron Castings
- D14—Machinery and Equipment
- D15—Railroad Welding

A brief review of a few more important standards follows in the same alphabetical order.

It should be noted that there is a strong and active Canadian participation on the AWS committees. This participation is dictated by the desire to keep welding standards in both countries at the same advanced level and without any major differences, so as to effectively support the high volume of trade characteristic of the economic ties between them.

AWS - A2.4-86

"Standard Symbols for Welding, Brazing, and Nondestructive Examination"

This Standard deals with the principles of graphic representation of welding and testing requirements and their application in practice. For that reason the full command of the symbols language must be considered of utmost importance in the proper and correct conveyance of welding and inspection information. Its graphic provisions cover all types of arc and resistance welds as well as brazed joints with their symbolic elements capable of defining preparation, fit-up, and execution of welding in terms of sizes, lengths, sequencing and type of finish and the use of a specified welding process.

The AWS A2.4 Code has been officially adopted by the CSA W59 Standard for application to Canadian welding and fabrication operations, although a few minor modifications have been introduced.

It should be noted that for greater convenience nondestructive testing can be specified by means of graphic symbols either separately or combined with welding information.

There should be no need to emphasize that a full and expert command of symbols is an unconditional prerequisite of an error-free communication of the design requirements from the engineer to the fabricator and from the fabricator to his shop and field personnel.

AWS - A3.0

"Standard Terms and Definitions"

The 1985 edition of this Code is published as American National Standard (ANSI). It supersedes the 1980 version. It is unquestionably an extremely important document as it defines all the standard terms in the language of welding. As is the case with any other language it is subject to continual evolution with the rapid technological growth making additional and pressing demands for upgrading and expansion. Without it no intelligent dialogue or sensible communication is possible.

Hence, it remains the responsibility of individual engineers, designers, inspectors, fabrication personnel, the academic and teaching community as well as the standards writing bodies to acquire a satisfactory level of proficiency in the use of correct welding terminology.

The 1985 edition incorporates major revisions and includes 946 terms and definitions, of which 155 are either new or represent significant changes of existing definitions, while additional 464 earlier definitions have been refined. Supplementary material includes 41 sketches and diagrams.

The extent of the changes, some of them in the basic concepts entrenched in long tradition and hence requiring major re-orientation makes the need for familiarization with the latest edition so much more urgent and imperative.

It should be noted that the extreme importance of this document dictated its official adoption by the standards writing bodies in Canada thus promoting its use in practice.

AWS - A4.3 - 86

"Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Weld Metal Produced by Arc Welding"

The importance of standard methods for measuring diffusible weld metal hydrogen has been recognized for many years but some of the methods used in the past, particularly collection of hydrogen over glycerine, have proved unreliable. AWS A4.3-86 provides for measuring diffusible hydrogen using either mercury displacement or gas chromatography but excludes glycerine, paraffin, and silicone oil.

The Standard covers requirements for the test weld which allow all the common arc welding processes to be tested. The collecting apparatus which is described has been designed to minimize handling of mercury. The method gives results closely agreeing with those obtained with the IIW mercury method.

AWS - A5

"Filler Metals"

A listing of AWS A5 Filler Metal Specifications is included in Module 6.

In terms of a general comment it should be pointed out, that through close liaison between the CSA and AWS committees a maximum effort is being made to keep the electrode specifications in both countries as identical as practically possible. However, some differences prevail. A notable one is in the test identifying an electrode as a "low hydrogen" (basic) electrode, where the AWS stipulates a maximum moisture content in the coating and the CSA maximum millilitres of diffusible hydrogen per 100 gram of weld metal using the glycerine test.

Another one would be a Controlled Hydrogen ("CH") designation for Canadian FCAW electrode classifications based on meeting specified maxima using the same test.

B2.1

"Standard for Welding Procedure and Performance Qualification"

This new Standard prescribes detailed requirements for welding procedure and welding performance (welder) qualifications. Its ambitions and ultimate objective is that it be referenced by other documents such as codes, standards, specifications or contracts, which currently may include their own qualification provisions, with these documents free to specify additional conditions and test criteria applicable to their end products. The reference here—amongst others—is to AWS, ASME and API codes.

Qualification variables for each welding process are clearly listed and all-encompassing procedure qualification requirements stated. Allowance is made for Standard Welding Procedure Specifications (WPS) expected to be eventually published by the AWS for which no qualification by test is required except for changes in variables beyond the ranges permitted. All other WPS are said to require individual qualification.

The second part of the Standard covers very comprehensively welder and welding operator qualifications. It permits workmanship (production) tests and stipulates standard qualification tests, with conditions defined for each.

Procedure qualifications are related to groupings of base metals in appropriate categories to minimize the number of tests and their frequency. An extensive tabulation of steel designations with their assigned material numbers and grouping is provided.

Classifications of filler metals into "F" numbers (usability characteristics) and "A" numbers (ferrous weld metal analyses) is also given with both classifications affecting procedure qualifications and the "F" classifications additionally affecting performance qualifications.

ANSI/AWS Structural Welding Codes

A series of structural welding codes carrying the letter designation "D1" as written by the AWS Structural Welding Committee has a number of common features as part of a concerted policy of this committee. These are:

- the structuring of clauses or sections (arrangement and sequencing of material) is kept identical as much as practically possible,
- in the area of strength of welds the allowable stress design method is used exclusively, except as noted in D1.4,
- the units are imperial units with SI (metric) soft conversion shown in brackets,
- for almost all standards (none for D1.4) commentaries are provided either as part of the published standard or separately.

The following is a brief review of the D1 Structural Welding Codes.

ANSI/AWS - D1.1

"Structural Welding Code - Steel"

As the most prominent of the D1 series this Code provides comprehensive rules pertaining to the construction of welded steel structures. It covers the design and strength of welds, qualification requirements for welding procedures and welding personnel, workmanship, inspection, and quality acceptance criteria.

The Code is arranged to show requirements common to all structures in Sections 1 to 7 and in Section 11 with specific and supplementary provisions presented separately in:

- Section 8 for buildings (statically loaded structures),
- Section 9 for bridges (dynamically loaded structures), and
- Section 10 for tubular structures.

The Code covers only arc welding processes and incorporates the concept of prequalified welding procedures in conjunction with the use of prequalified details of joints. It includes a separate section on stud welding.

It is comparable to the CSA Standard W59 "Welded Steel Construction" except for its extensive coverage of tubular structures and its own requirements for qualification of welding procedures and welding personnel with regard to which the CSA Standard references the CSA W47.1 certification code. However, these qualification requirements in both CSA and AWS Codes can be said to be reasonably equivalent.

The AWS D1.1 Code jointly with its commentary has been published on a yearly basis. As a prestigious document it enjoys wide recognition even outside the USA borders.

ANSI/AWS - D1.2

"Structural Welding Code - Aluminum"

Responding to the need for a code for welded aluminum structures—similar to that for steel—a special sub-committee within the main structural welding committee was formed in 1979 and led to the first publication of the D1.2 Code in 1983 together with a separate commentary.

In accordance with the basic policy governing all D1 Standards, sections 1 to 7 include requirements common to all types of aluminum structures while sections 8, 9, and 10 cover non-tubular (static loads), non-tubular (dynamic loads), and tubular structures, respectively.

The common provisions cover the design of welded connections, workmanship, technique, qualification, inspection, strengthening and repair of existing structures.

Provisions are included only for the:

- GMAW - gas metal
 - GTAW - gas tungsten
- } arc welding processes

In section 10 on tubular structures distinction is made between end products classified as:

- class I - luminaires, traffic signals, overhead sign supports, and
- class II - all other tubular structures.

It should be noted that no provisions for pre-qualified procedures are included, although recommended joint details are shown.

Commentary is available and its 1983 edition appears as a separate publication.

ANSI/AWS - D1.3

"Structural Welding Code - Sheet Steel"

This Code provides rules for arc welding of black, galvanized or coated sheet steel as used in structures. Its application covers welding of steel deck, steel panels, storage racks and framing members such as studs and joists.

Welding processes include the :

- SMAW - shielded metal
 - GMAW - gas metal
 - FCAW - flux cored
 - SAW - submerged
- } arc welding processes

Comprehensive design coverage is provided for:

- arc spot
 - arc seam
 - fillet
 - single flare bevel and V-groove
- } welds

Detailed workmanship, technique, and stringent welding procedure and welder qualification requirements are shown. A brief commentary is included as an appendix to the Code.

It is important to note that welder or welding operator qualification is required irrespective of any qualification under other codes. This is in recognition of the special skills involved in welding of thin materials.

ANSI/AWS - D1.4

"Structural Welding Code - Reinforcing Steel"

The self-contained D1.4 Code covers all welding requirements in the area of reinforced concrete construction. It provides for the use of SMAW, GMAW, FCAW, pressure gas, and thermit welding processes. It lists the strength of welds based on the allowable stress and the ultimate strength methods. Structural details cover types of splices, insert plate connections, and anchorages. Requirements for workmanship, technique, quality, inspection, and qualification of procedures and welders are explicitly stated.

No prequalification is allowed and currently no commentary provided.

ASME - American Society of Mechanical Engineers

ASME through its Council on Codes and Standards is recognized worldwide as a major standards setting organization. Founded in 1880 as an educational and technical society it continues to pursue its basic objectives through dissemination of technical information and promotion of economic, reliable, and safe practices in a wide area of product oriented engineering and manufacturing activities.

One of the avenues used most effectively towards this objective is standards development. ASME directs this particular activity through its ten Code and Standards Boards, which exercise full jurisdiction over the standards generating committees, each responsible for a specific area of standards development. To ensure full implementation of the standards it uses accredited companies for certification of compliance with its codes.

Of primary interest is the Pressure Technology Board and specifically the Pressure Vessel Codes under the auspices of the ASME Boiler and Pressure Vessel Code Committee. The function of the committee is to establish rules of safety covering design, fabrication, inspection and testing of boilers, pressure vessels, and associated equipment during original construction. In formulating these rules consideration by the committee is given to the needs of the manufacturers, users, inspectors, and regulatory agencies. The objective of the rules is to provide a margin for deterioration in service so as to ensure a reasonably long and safe period of usefulness. Advances in material technology and new experience are also considered.

The ASME Boiler and Pressure Vessel Code is published every three years. It has been adopted in 46 states in the USA, numerous municipalities, all provinces in Canada (see CSA B.51) and is used in several other countries. Addenda are published regularly to maintain an updated status of the code.

For general information the following are the 11 sections of the ANSI/ASME Boiler and Pressure Vessel Code:

Sections:

- I Power Boilers**
- II Material Specifications**
 - Part A—Ferrous Materials
 - Part B—Nonferrous Materials
 - Part C—Welding Rods, Electrodes and Filler Metals
- III Subsection NCA—General Requirements for Division 1 and Division 2**
 - III Division 1**
 - Subsection NB—Class 1 Components
 - Subsection NC—Class 2 Components
 - Subsection ND—Class 3 Components
 - Subsection NE—Class MC Components
 - Subsection NF—Component Supports
 - Subsection NG—Core Support Structures
 - Appendices
 - III Division 2—Code for Concrete Reactor Vessels and Containments**
- IV Heating Boilers**
- V Nondestructive Examination**
- VI Recommended Rules for Care and Operation of Heating Boilers**
- VII Recommended Rules for Care of Power Boilers**
- VIII Pressure Vessels**
 - Division 1
 - Division 2—Alternate Rules
- IX Welding and Brazing Qualifications**
- X Fiberglass-Reinforced Plastic Pressure Vessels**
- XI Rules for Inservice Inspection of Nuclear Power Plant Components**

Of greater interest is section IX and its part dealing with welding procedure and performance qualifications. A cursory review of those in comparison with similar requirements in the CSA W47.1 Standard would reveal that, amongst others, differences exist in:

- the definition of essential variables, these being more numerous and more restrictive in W47.1,
- section IX listing a separate set of variables where impact testing is a part of procedure qualification,
- performance qualification, with section IX:
 - (i) providing for a 6G assembly (inclined pipe section),
 - (ii) ruling differently on the extent of validity on basis of a test in one given position,
 - (iii) not specifying a mandatory time limit for checktesting,
 - (iv) not permitting mobility for qualified welders.

Many other differences exist between section IX and W47.1 but their discussion is beyond the scope of the module.

API - American Petroleum Institute

The American Petroleum Institute founded in 1919 represents the domestic petroleum industry. Its activities are directed by committees composed of members of all sectors of that industry. These committees develop training programs, standards and recommended practices, they sponsor research, and provide statistical information, all within the premise of technological advancement and in the interest of the general public.

A brief reference to a few welding related specifications or recommended practices (RP) in two distinctive areas will serve well to illustrate the API's respectable contribution to the development of standards.

Offshore structures are covered in RP 2A, "Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms". The welding requirements of RP2A essentially follow AWS D1.1. There are separate specifications for steel and fabricated pipe for offshore structures.

RP 2X, "Recommended Practice for Ultrasonic Examination of Offshore Structural Fabrication and Guidelines for Qualification of Ultrasonic Technicians" contains recommendations for determining the qualifications of technicians conducting inspections on offshore structural fabrication using ultrasonic pulse echo inspection devices. Recommendations are also given for control of ultrasonic inspections into a general quality control program. The interrelationship between joint design, significance of flaws in welds, and the ability of an ultrasonic technician to detect critical size defects are also discussed.

In the important area of welded steel storage tanks for refinery service the standards of special significance are Std 650, "Welded Steel Tanks for Oil Storage" and Std 620, "Recommended Rules for Design and Construction of Large Welded, Low-Pressure Storage Tanks".

Std 650 covers material, design, fabrication, erection, and testing requirements for vertical, cylindrical, above-ground, closed- and open-top, welded steel storage tanks, in various sizes and capacities, for internal pressures approximating atmospheric pressure. It also includes an alternate basis for shell design, as well as one for calculating tank shell thickness.

Std 620 covers the design and construction of large, welded, field-assembled storage tanks used for petroleum intermediates and finished products operated at a gas pressure of 15 psig and less, down to an internal gas pressure close to atmospheric pressure, which are not now provided for in API Std 650.

All welding provisions have been taken either from AWS or section IX of ASME Boiler and Pressure Vessel Code.

ASTM - American Society for Testing and Materials

ASTM was founded in 1898 as the American Section of the now defunct International Association of Testing Materials. It became an independent organization in 1902 with committees on steel, nonferrous metals, cement and paints. Although expanding its scope it still remained primarily a metals society until the 1960's when it consciously enlarged its scope to accommodate the development of standards on characteristics and performance of materials, products, systems, and services and the promotion of related knowledge.

ASTM helped to organize ANSI and supports its co-ordinating efforts and correspondingly its standards are voluntary and full consensus standards.

Although without specific relation to welding its authoritative position on materials warrants a few comments on the general classification of these materials.

Codes and Standards

The present system of designating committees by means of letters and numbers, although considered outmoded under the pressure of present day needs, is as follows:

- Committee
- A - Ferrous Metals
(Al - Steels, to mention one)
 - B - Nonferrous Metals
 - C - Cementitious, Ceramic, Concrete, and Masonry Materials
 - D - Miscellaneous Materials
 - E - Miscellaneous Subjects
 - F - Materials for Specific Applications
 - G - Corrosion, Deterioration and Degradation of Materials

The 48 parts of the "Annual Book of the ASTM Standards" are published on a regular basis.

INTERNATIONAL STANDARDS ORGANIZATIONS

The expanding volume of international trade brings to realization the growing urgency and the pressing need for national and international standards criteria which would not only be less obstructive but rather promote and foster the free exchange of goods across borders.

Co-operative international action in providing standards for countries not having the capability or expertise to produce their own has long been in evidence. However, what is presently becoming more visible is the recognition of the dual need:

first—by more active participation to significantly influence international standards for greater protection of national interests, and

second—to bring international consensus to bear on potential modifications to national standards to reduce differences.

There are two international standards developing organizations of long standing, whose accomplishments have been widely recognized. They are discussed next.

International Standards Organization (ISO)

The objective of ISO formed in 1946 is to promote development of standardization with a view of facilitating international exchange of goods and services. The scope of ISO covers standardization in all fields except electrical and electronic engineering standards, which are the responsibility of IEC discussed briefly next. Its head office is located in Geneva, Switzerland.

The members of ISO are those bodies most representative of standardization in a given country. Only one such organization in each country is admitted to membership.

In Canada the Canadian National Committee on ISO (CNC/ISO) is responsible, through the Standards Council of Canada (SCC) for general supervision and direction of Canada's participation in the work of ISO. Accredited standards writing organizations are encouraged to use recognized international standards as a basis for national standards, whenever Canadian practices and conditions permit.

In the USA the American National Standards Institute (ANSI) is acting in the same capacity. The enormous amount of work as measured by thousands of published standards is carried by hundreds of technical committees, subcommittees, and working groups.

Three of these technical committees with strong Canadian participation are:

- 1) ISO/TC44 "Welding and Allied Processes" comprising 12 subcommittees. The scope of this TC includes standardization involving several welding processes (gas, electric arc, resistance, induction), terminology, symbols, testing methods, filler materials, design rules, welder qualification, safety and health.
- 2) ISO/TC 135 "Nondestructive Testing". It comprises 7 subcommittees covering terminology, surface, acoustical, electric and magnetic, radiation and leak detection methods. Personnel qualifications are also included.
- 3) ISO/TC 167 "Steel Structures" operating through two subcommittees:
 - SC1 - Materials and Design
 - SC2 - Fabrication and Erection

This ISO TC can claim the most active Canadian participation and input of expertise resulting in a considerable and visible impact on formulation of the prospective ISO standards.

Secretaries for the Technical Committees are provided by different countries: for TC44 - France; TC 135 - USSR; TC 167 - Norway and United Kingdom for the respective subcommittees.

Credit should also be given to the *International Institute of Welding (IIW)* which, as a principally research and technical body concerned with welding, has throughout the years made a unique contribution to the development of international standards related to welding through ISO.

As a matter of fact on the basis of a recent mutual agreement between ISO and IIW, the latter will be permitted to prepare standards, to which full recognition will be given by ISO.

International Electrotechnical Commission (IEC)

The IEC was formed in 1906 with the objective to promote international co-operation on all questions of standardization in the fields of electrical and electronic engineering. Its head office is located in Geneva, Switzerland.

The Canadian National Committee of the IEC (CNC/IEC) is responsible to the Standards Council for the general supervision and direction of Canada's participation in the work of IEC. ANSI in the US performs the same function. Since the IEC has no direct bearing on welding standardization the brief information as given is considered adequate.

NATIONAL STANDARDS ORGANIZATIONS IN OTHER COUNTRIES

A number of leading standards-writing organizations are known throughout the world. The following is intended to identify them in several countries with a few background notes, where possible.

UNITED KINGDOM:

BRITISH STANDARDS INSTITUTION - BSI

Incorporated by Royal Charter, BSI is the independent national body for the preparation of British Standards. It is also the UK member of ISO and the UK sponsor of the British National Committee of IEC.

FEDERAL REPUBLIC OF GERMANY:

DEUTCHES INSTITUT FÜR NORMUNG - DIN

DIN, the German Institute for Standardization is a non-profit organization, independently administered, representing a cross-section of industry and trade and formally recognized by the government of the Federal Republic of Germany as the standards body within its territorial boundaries and West Berlin.

A significant proportion of welding related DIN standards is prepared in co-operation with the working groups of the Technical Committees of the German Welding Society (Deutsches Verband für Schweisstechnik - DVS) under the direction of the Welding Standards Committee of DIN.

It is worth noting that a number of DIN standards are published in English. DIN is a member of ISO and sponsor of participation in IEC.

FRANCE:

ASSOCIATION FRANCAIS DE NORMALISATION - AFNOR

An independent national standards-writing organization funded by industry and grants from government.

SOUTH AFRICA:

SOUTH AFRICAN BUREAU OF STANDARDS - SABS

AUSTRALIA:

STANDARDS ASSOCIATION OF AUSTRALIA - SAA

Incorporated by Royal Charter in 1950. Supported by grants from government, subscription from members, and sales of publications.

JAPAN:

There are a number of standards-writing organizations in Japan. As a result of longtime evolution, the **Japanese Industrial Standards Committee (JISC)** has emerged as the government empowered committee to issue Japanese Industrial Standards - (JIS). These cover mainly the field of industrial and mineral products.

There are additionally standards designated as:

- **NDIS**— published by the Japanese Society for Non-Destructive Inspection, and
- **WES**— published by the Japanese Welding Engineering Society. These relate closely to welding and cover amongst others certification of welding engineers and performance qualifications.

CLASSIFICATION SOCIETIES

Sight should not be lost of the different breed of organizations which, although concerned primarily with shipping and offshore structures, play a very influential role in the area of welded fabrication. The contention is that a brief discussion on their objectives will greatly assist in placing their activities in proper perspective.

The reference here is to classification societies. This designation dates back to the early origins of these societies, when classification of ships was indeed their primary function. However, their present operations activated by the acquired expertise in highly specialized areas have expanded to cover certification, verification, inspection, and technical advisory services, all of which have collectively added to the prestige and worldwide reputation they rightly enjoy.

Discussed briefly will be:

- American Bureau of Shipping
- Lloyd's Register of Shipping
- Det Norske Veritas
- Nippon Kaiji Kyokai

American Bureau of Shipping - ABS

The responsibility of ABS as a classification society is to assure that the merchant ships and marine structures presented to it comply with the Rules that the society has established for their design, construction, and periodic survey. Classification is a representation by the society as to the structural and mechanical fitness of a vessel for intended service in accordance with its Rules.

ABS develops and updates these Rules through a structure of technical committees, amongst them: Materials, Mobile Offshore Drilling Units, Offshore Installations, Welding and Electrical Engineering Committees. Its technical staff of surveyors trained in the skills of naval architecture, marine engineering, and associated disciplines is employed to review designs. Field surveyors witness testing of materials, machinery, and components at the manufacturers' plants and fabricators' shops. They also verify workmanship and quality as complying with the Rules.

ABS sponsors or co-sponsors research programs related to industrial and marine engineering. Its activities reach many countries and in most of them it maintains representation.

Lloyd's Register of Shipping

Lloyd's is an independent, non-commercial classification society, whose objective is to provide inspection and technical advisory services primarily for ship-building, but also for marine, non-marine, and offshore engineering projects.

Lloyd's Register is a certification/verification authority, recognized by governments throughout the world. It is a worldwide task force of experienced professionals who provide the surveying and inspection service, which in turn monitors engineering activities and ensures that construction standards are obtained and maintained throughout a remarkable variety of projects.

It is also an author of many Rules and Regulations pertaining to ship, marine, and offshore construction.

Det Norske Veritas (DnV)

DnV is a classification society of equally renowned international reputation, as ABS and Lloyd's Register. As the latter, it also provides an extensive range of services besides certification and verification including solutions to complex problems of safe marine transportation and offshore resources development.

DnV publishes internationally recognized Rules and Supplementary Guidelines related to shipping, energy and offshore construction.

It has the recognition as certifying authority by many governments and maintains representation in many countries.

Nippon Kaiji Kyokai

This classification Society is the Japanese national society with objectives and activities similar to those of Lloyd's and DnV.

APPENDIX

LOCATING CODES & STANDARDS

CANADA

The Standards Council of Canada

Head Office

350 Sparks Street, Suite 1203

Ottawa, K1R 7S8

Telephone: (613) 238-3222

International Standardization Branch

2000 Argentea Road, Suite 2-401

Mississauga, Ontario, L5N 1V8

Telephone: (416) 826-8110

The following are the names and addresses of the five standards-writing organizations accredited by the Standards Council to write and publish National Standards in Canada.

Bureau de Normalisation du Québec

50 est, rue St. Joseph

Québec, Québec, G1K 3A5

Telephone: (418) 643-5114

Canadian Gas Association

55 Scarsdale Road

Don Mills, Ontario, M3B 2R3

Telephone: (416) 447-6465

Canadian General Standards Board

Canadian Government Publishing Centre

Supply and Services Canada

Ottawa, Ontario, K1A 0S9

Telephone: (819) 997-2560

Canadian Standards Association

Standards Sales Service

178 Rexdale Boulevard

Rexdale, Ontario, M9W 1R3

Telephone: (416) 747-4044

Underwriters' Laboratories of Canada

7 Crouse Road

Scarborough, Ontario, M1R 3A9

Telephone: (416) 757-3611

UNITED STATES OF AMERICA

American National Standards Institute (ANSI)
1430 Broadway
New York, NY 10018
(212) 354-3300

A catalogue is issued yearly by ANSI and is available for purchase. ANSI is also the agent for all standards issued by the International Organization for Standardization (ISO). A catalogue of ISO Standards is also available for purchase from ANSI.

Other standards-writing organizations with catalogues of their documents are:

American Society of Mechanical Engineers (ASME)
345 East 47th Street
NEW YORK, NY 10017
(212) 705-7703

American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, PA 19103
(215) 299-5400

Underwriters' Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062
(312) 272-8800

The National Bureau of Standards (NBS) also has a Standards Information Service (SIS). NBS-SIS has a collection of over 240,000 codes and standards consisting of voluntary standards, state purchasing standards, US government, and foreign standards.

NBS-SIS can be contacted at:
Standards Information Service
Room B162, Building 225
U.S. Department of Commerce
National Bureau of Standards
Washington, DC 20234
(301) 921-2587

An NBS-SIS search will result in a list of all applicable standards, the name and address of the issuing organizations, the standard number, title, price if known, and the year of publication or latest revision. NBS-SIS will not supply a copy of the code or standard.

If additional help is needed in finding a code or standard, the Safety Division will try to assist.
Contact:

Manager—Codes & Safety
National Elevator Industry, Inc.
600 Third Avenue
New York, NY 10016
(212) 986-1545

American Petroleum Institute (API)

API Headquarters
1220 L Street, N.W.
Washington, D.C. 20005
(202) 682-8000

Production Department
American Petroleum Institute
211 N Ervay, Ste 1700
Dallas, TX 75201
(214) 741-6791

Central Abstracting & Indexing Service
American Petroleum Institute
156 William St, 4th Floor
New York, NY 10038
(212) 587-9660

American Welding Society (AWS)

550 NW LeJeune Road
P.O. Box 351040
Miami, FL 33135

UNITED KINGDOM

British Standards Institution (BSI)

2 Park Street
London, W1A 2B2
England
Tel: 01-629-9000
Telex: 266933

FEDERAL REPUBLIC OF GERMANY

Deutsches Institut für Normung (DIN)

Burggrafenstrasse 4-10
Postfach 1107
D-1000 BERLIN 30

FRANCE

Association Francais de Normalisation (AFNOR)

Tour Europe Cedex 7
Paris 92080

REPUBLIC OF SOUTH AFRICA

SA Bureau of Standards

Private Bag X191

Pretoria

Republic of South Africa

AUSTRALIA

Standards Association of Australia (SAA)

Standards House

80 Arthur St.

North Sydney

New South Wales

or

P.O. Box 458

North Sydney 2060

New South Wales

Telex: 26514

Tel: Sydney 929 6022

CLASSIFICATION SOCIETIES

UNITED KINGDOM

Lloyd's Register of Shipping

71 Fenchurch Street

London, EC3M 4BS

England

Telephone: 01-709 9166

Cables: Committee, London, EC3

Telex: 888379

USA

American Bureau of Shipping (ABS)

65 Broadway

New York, NY 10006

U.S.A.

NORWAY

Det Norske Veritas (DnV)

Head Office: Veritasveien 1, 1322 Høvik

P.O. Box 300, 1322 Høvik,

Norway

Telegrams: Veritas, Oslo

Telex: 76192

Telephone (International Nos.): + 47 2 12 99 00

Telephone (National Nos.): (02) 12 99 00

JAPAN

Nippon Kaiji Kyokai

4-7, Kioi-cho, Chiyoda-ku,

Tokyo 102

Japan

CODES AND STANDARDS

MODULE 13

Guides & Exercises

To obtain maximum benefit from this module, we suggest that you follow this guide and complete the exercises as indicated. It is important that you work through the text methodically, studying each section thoroughly before moving on. The exercises are designed to give you an indication of whether you have learned the material and can move on or whether you need to go back and study the section again.

Do the exercises honestly. They will not help you unless you take them seriously. If you get a question wrong, go back through the text until you understand where you have gone wrong and know the correct answer.

The length of time required to complete the module will vary from student to student. Find your own pace. Do not rush. Remember you are trying to learn something, not win a race.

Some people like to underline sections when they read a text. We suggest that you use caution if you do this. What you think is important first time you read it may be different after reading it three times. We suggest you read a section three times thoroughly before highlighting anything.

The last exercise is designed to give you an indication of whether you are ready to take the WIC closed-book exams. The exercise questions are of a similar standard to the official exams. Do not take the exam until you feel you are ready, and you may wish to study several Modules before taking the exams on each. The details of the examination procedures are on a separate sheet.

If you have any difficulties with this Module, do not hesitate to ask for help. You may find you learn more by attending some of the seminars and you should also contact your local WIC Chapter to see if they can be of assistance. Remember, if you fail the examination you can always try again later.

MODULE 13

Guide 1

Carefully read pages 1 to 8 and answer the following questions:

1. True or false?

The Standards Council of Canada defines a standard as a "document recording approved rules for an orderly approach to a specific activity".

2. Most standards are:

- a) prepared by trade organizations
- b) legislated by governments
- c) generated through voluntary efforts

3. Name four key interest groups that should be represented on a committee developing a standard.

4. Which body is responsible for administering CSA welding standards?

5. True or false?

The CSA is the only organization accredited by the Standards Council of Canada for developing standards.

6. The final approval of draft standards on welding developed by various CSA technical committees is given by:

- a) the technical committee itself
- b) the Standards Policy Board of CSA
- c) the Federal Government
- d) the Standards Steering Committee on Welding
- e) the Canadian Welding Bureau

Check your answers for accuracy. If any of your answers are wrong, re-study the guide subject matter in the text until you understand it.

MODULE 13

Guide 2

Carefully read pages 9 to 19 and answer the following questions:

1. The CSA Standard W47.1 is a standard for:
 - a) certification of a specific welded product
 - b) certification of companies for welding of pressure vessels
 - c) certification of companies for fusion welding of steel structures
2. What are the three main categories of qualified personnel required by the W47.1 Standard?
3. What is the distinction in the relation between the company and the engineering personnel in the case of Division 1 and 2?
4. The certified company is obligated to report to the Bureau any changes in:
 - a) welders, engineering and supervisory personnel
 - b) welding procedure specifications and related data sheets
 - c) only welders
5. Does an engineer qualified for one company for welding design and welding procedure and practice retain his qualification upon moving to another certified company?
6. A change in which variables of a welding procedure requires a new qualification and why?
7. True or false?

"A qualified welder loses his qualification upon leaving for another certified company."
8. True or false:

"the certification requirements for the fabricator in the CSA W47.2 and W55.3 Standards are not generally patterned after those in the W47.1 Standard."

Check your answers for accuracy. If any of your answers are wrong, re-study the guide subject matter in the text until you understand it.

MODULE 13

Guide 3

Carefully read pages 20 to 29 and answer the following questions:

1. The 1984 editions of the W59 Standard include:
 - a) English versions in both SI (metric) and imperial units and a French version in SI (metric) units with provisions in all versions for the Allowable stress (ASD) and the Limit States Design (LSD) methods
 - b) only English versions with imperial units and ASD provisions
 - c) English and French versions with only metric units, ASD and LSD provisions
2. The 1984 editions of W59 Standard:
 - a) cover arc welding and resistance welding processes
 - b) include provisions for stud welding
 - c) make mandatory use of inspection companies certified to CSA W178 Standard
3. The 1984 editions of the W59 Standard:
 - a) cover workmanship, inspection procedures, and prescribe in detail qualification of welders and welding procedures
 - b) do not recognize the concept of prequalification
 - c) include provisions for fatigue design
4. In the 1984 editions of the W59 Standard:
 - a) all clauses apply to all structures irrespective of the type of loading
 - b) only clauses 1 to 10 are common to all types of structures
 - c) all clauses apply to statically loaded structures
5. The CSA W178 Standard:
 - a) uses the qualification concept of the W47.1 Standard
 - b) is concerned only with inspection and testing procedures
 - c) deals only with qualifications of 3 levels of inspection personnel
6. The CSA W178.2 Standard:
 - a) provides for examinations on inspection standards for only 5 categories of products
 - b) stipulated educational and experience requirements for each of the 3 levels of inspectors
 - c) does not recognize the American Welding Society's (AWS) Inspector qualifications

Check your answers for accuracy. If any of your answers are wrong, re-study the guide subject matter in the text until you understand it.

MODULE 13

Guide 4

Carefully read pages 30 to 38 and answer the following questions:

1. The CSA W186 Standard:
 - a) is a design and certification standard also providing workmanship and inspection requirements
 - b) uses SI (metric) units and is based on the Allowable Stress Design (ASD) method
 - c) includes provisions for the Submerged Arc Welding process (SAW)
2. The CSA W186 Standard:
 - a) does not give even a partial recognition to companies certified under the W47.1 Standard
 - b) has adopted the certification principle of the W47.1 Standard
 - c) provides for comprehensive design guidance by means of extensive design examples in the Appendix
3. True or False?

"The CSA B51 Standard is used by provincial governments' Boiler and Pressure Vessel Acts to supplement the principal requirements of the Acts".
4. True or False?

"The National Building Code is imposed on authorities responsible for public safety in buildings"
5. The CSA S16.1 Standard in its 1984 edition:
 - a) is based on the Allowable Stress Design (ASD) method
 - b) refers to CSA W59 and W55.3 Standards for welding design in arc and resistance welding respectively
 - c) does not require certification of fabricators to the W47.1 Standard
6. True or False?

"The CSA Z184 Standards refer to the CSA W47.1 Standard for qualification requirements for welders and welding requirements".
7. The Ontario Highway Bridge Design Code (OHBD):
 - a) requires welding design and practice to conform to the CSA W59 Standard
 - b) requires fabricators to be certified to Division 1 of the W47.1 Standard
 - c) includes a comprehensive Fracture Control Plan

Guide 4 (continued)

8. True or False?

"The fatigue provisions of CSA Standards W59, S6, S16.1 and of the OHBD Code are identical with respect to welding details".

9. The CSA G40.21 Standard provides for:

- a) standard quality steels each with its own specific characteristics for a given application**
- b) impact properties to be specified by the purchaser (within certain limitations)**

Check your answers for accuracy. If any of your answers are wrong, re-study the guide subject matter in the text until you understand it.

MODULE 13

Guide 5

Carefully read pages 39 to 49 and answer the following questions:

1. The American National Standards Institute (ANSI):
 - a) is a standards developing body
 - b) accepts standards based on balance, consensus, and review
 - c) co-ordinates US participation in ISO and IEC
2. The American Welding Society (AWS):
 - a) earned its reputation primarily through formulation of welding standards
 - b) has its technical committees working only in areas of Processes and Applications
3. True or false?

"The AWS A2.4 Standard on symbols has been adopted with minor modifications by the CSA W59 Standard."
4. True or false?

"The AWS B2.1 Standard is intended to totally replace all welding procedure and performance qualification requirements of the existing US codes."
5. The AWS D1.1 Structural Welding Code-Steel:
 - a) is identical in coverage to the CSA W59 Standard
 - b) includes welding procedure and performance qualification requirements
 - c) has a separate section on tubular structures
6. Are provisions for prequalified procedures included in AWS D1.2 Structural Welding Code-Aluminum?
7. True or false?

"The position of ASME Section IX on welding procedure and performance qualification is identical to that of the CSA W47.1 Standard."

Check your answers for accuracy. If any of your answers are wrong, re-study the guide subject matter in the text until you understand it.

MODULE 13

Guide 6

Carefully read pages 50 to 55 and answer the following questions:

1. The need for international standards arises from:
 - a) the protection of national interests and the recognition that differences between national and international standards must be reduced
 - b) co-operation to assist countries having no standards
2. The International Standards Organization (ISO):
 - a) covers standardization in all fields except electrical
 - b) admits more than one national body
3. True or false?

"The International Institute of Welding (IIW), principally a research and technical body, while supporting the development of standards can never write them."
4. The national standards organizations in other countries are:
 - a) BSI in the Federal Republic of Germany
 - b) AFNOR in France
 - c) BSI in South Africa
 - d) DIN in Australia
 - e) SAA in Australia
 - f) JIS in Japan
5. True or false?

"All classification societies are only concerned with ship building and marine engineering."

Check your answers for accuracy. If any of your answers are wrong, re-study the guide subject matter in the text until you understand it.

MODULE 13

ANSWERS

Guide 1

1. true
2. c)
3. producer
4. the Canadian Welding Bureau
5. false
6. d)

Guide 2

1. c)
2. engineering, supervisory and welding personnel
3. engineering personnel must be employed in case of Division 1 and are retained in case of Division 2
4. a), b)
5. no
6. a change in an essential variable, as such change is considered to adversely affect the properties and soundness of welded joints
7. false
8. false

Guide 3

1. a)
2. b)
3. c)
4. b)
5. a)
6. b)

Guide 4

1. a)
2. b), c)
3. true
4. false
5. b)
6. false
7. a), c)
8. true
9. a), b)

Answers continued

Guide 5

1. b), c)
2. a)
3. true
4. false
5. b), c)
6. no
7. false

Guide 6

1. a), b)
2. a)
3. false
4. b), e), f)
5. false

MODULE 13

TEST

This test is designed to determine whether you are ready to attempt the formal examination.

Complete the ANSWER SHEET and compare the results with the TEST KEY. If you score less than 70% we suggest you re-study the material.

1. The final approval of draft standards on welding developed by various CSA committees is given by:
 - (a) Canadian General Standards Board
 - (b) Canadian Welding Bureau
 - (c) Standards Policy Board of CSA
 - (d) pertinent technical committee itself
 - (e) CSA Standards Steering Committee on Welding
2. Certification under the CSA W47.1 Standard pertains solely to:
 - (a) qualification of welders
 - (b) qualification of supervisors and designated engineering personnel
 - (c) qualification of procedures and documentation of suitable equipment
 - (d) items under (a) and (b)
 - (e) items under (a), (b) and (c)
3. The CSA W47.1 Standard required:
 - (a) impact testing as part of procedure qualification
 - (b) requalification of engineering personnel upon change of employment to another certified company
 - (c) check testing of welders each year
 - (d) only radiography for testing of *all* welders' test assemblies
 - (e) a retained engineer for welding practice in Division 3
4. The CSA W47.2 Standard:
 - (a) restricts its application to thicknesses greater than 6mm
 - (b) uses only plate assemblies for welder qualifications
 - (c) introduces its own gradation for welder qualifications
 - (d) includes the SAW process
 - (e) does not employ the fracture test as part of procedure qualifications
5. The CSA W59 Standard:
 - (a) covers arc welding and resistance welding processes
 - (b) makes certification to W47.1 and W178 mandatory for the fabricator and inspection company respectively
 - (c) has no provisions for stud welding
 - (d) recognizes the concept of prequalification
 - (e) has no provisions for plug welds

MODULE 13

TEST continued

6. The CSA W59 Standard:
- (a) includes provisions for the Allowable Stress Design (ASD) method only
 - (b) includes provisions for the Limit States Design (LSD) method only
 - (c) has comprehensive fatigue design provisions
 - (d) has no listing of "pre-approved" materials
 - (e) does not include acceptance standards for welds
7. The CSA W178 Standard :
- (a) encompasses the whole organization or its specific division performing welding inspection
 - (b) is administered by the CGSB
 - (c) involves only qualification of inspection personnel
 - (d) is concerned only with inspection and testing procedures
 - (e) provides no separate categories for certification
8. The CSA W186 Standard:
- (a) has no provisions for preheat
 - (b) includes the SAW process
 - (c) uses the Allowable Stress Design (ASD) method
 - (d) is a design and certification standard with clauses on workmanship and inspection
 - (e) makes no allowance at all for companies certified under CSA W47.1
9. Which of the following is true?
- (a) ANSI is a standards developing body
 - (b) AWS D1.1 has no provisions for qualification of welders and welding procedures
 - (c) AWS A2.4 deals with symbols for welding and inspection and has been adopted by the CSA W59 Standard
 - (d) AWS D1.2 has no provisions for fatigue design
 - (e) AWS D1.3 deals only with arc welding processes
10. Which of the following is true?
- (a) the provisions of ASME Boiler and Pressure Vessel Code section 1X has not been adopted or referred to by any CSA standard
 - (b) API provides code coverage for steel tanks for oil storage and offshore structures
 - (c) ASTM is only concerned with metals
 - (d) ISO provides standardization in all fields
 - (e) All classification societies are exclusively concerned with ship building

Welding Institute of Canada

Answer Sheet

Module 13

Complete the "Answer Sheet" and compare the results with the "Test Key". If you score less than 70% we suggest you re-study the material.

Please circle only ONE letter corresponding to the answer you think is most correct.

QUESTION	ANSWER				
1	a	b	c	d	e
2	a	b	c	d	e
3	a	b	c	d	e
4	a	b	c	d	e
5	a	b	c	d	e
6	a	b	c	d	e
7	a	b	c	d	e
8	a	b	c	d	e
9	a	b	c	d	e
10	a	b	c	d	e

The answer sheet below is provided in the event you wish to re-test yourself.

QUESTION	ANSWER				
1	a	b	c	d	e
2	a	b	c	d	e
3	a	b	c	d	e
4	a	b	c	d	e
5	a	b	c	d	e
6	a	b	c	d	e
7	a	b	c	d	e
8	a	b	c	d	e
9	a	b	c	d	e
10	a	b	c	d	e

Welding Institute of Canada

Test Key

Module 13

Compare your answer sheet to this key

QUESTION	ANSWER				
1	a	b	c	d	(e)
2	a	b	c	d	(e)
3	a	(b)	c	d	e
4	a	b	(c)	d	e
5	a	b	c	(d)	e
6	a	b	(c)	d	e
7	(a)	b	c	d	e
8	a	b	c	(d)	e
9	a	b	(c)	d	e
10	a	(b)	c	d	e